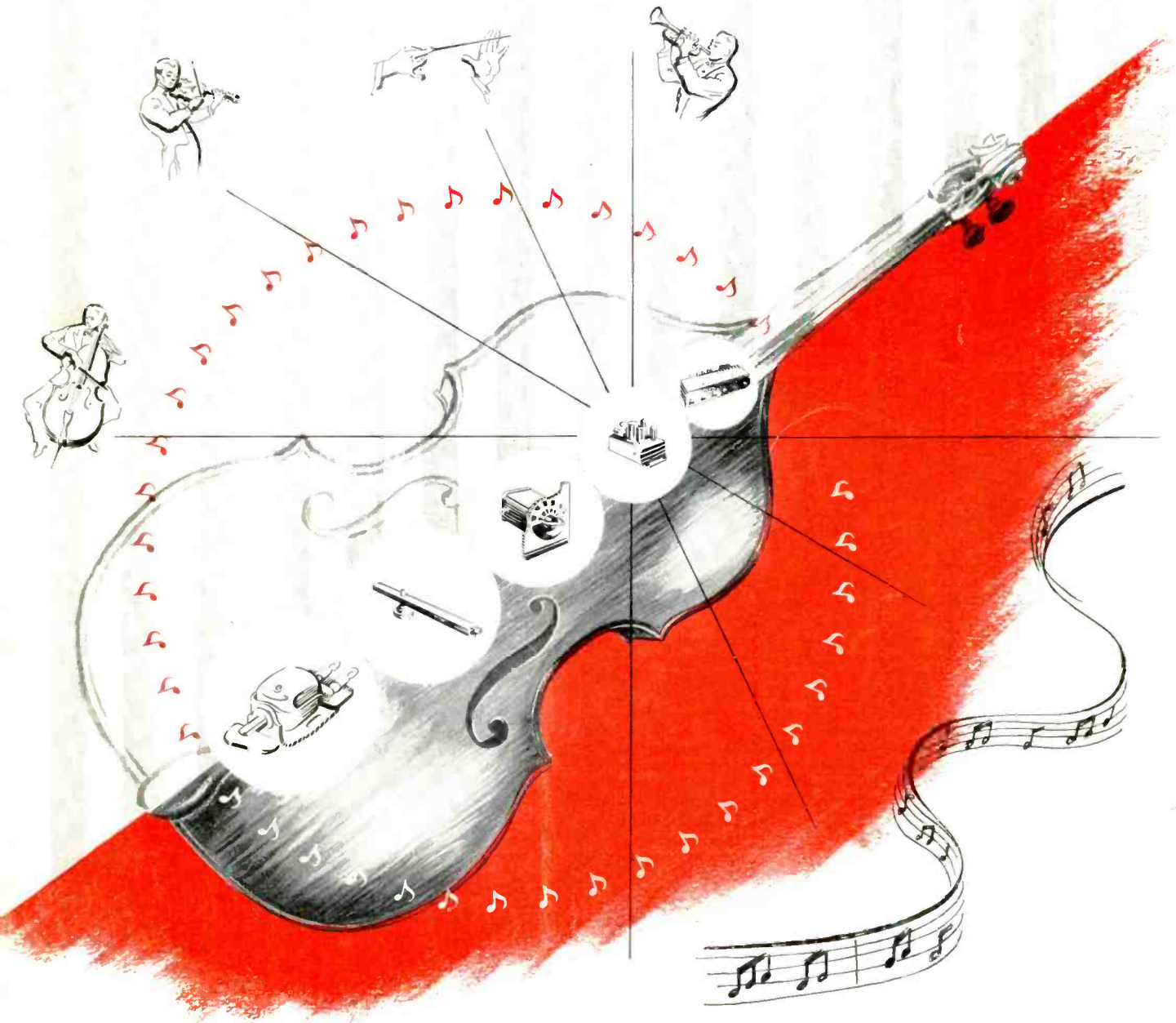


Mechanical Impedance of Pickups—See Page 19

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----- JUNE 1953 -----

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COVER

In this illustration we symbolize the binding relationship which links artistry and science in the world of Audio. In no other branch of electronics is the success of scientific achievement measured so thoroughly by the ability to interpret aesthetic values of composition and performance. There is no better example of such intermingling of practical science and creative thinking than Pickering & Co., all of whose products are designed for reproduction of recorded sound in the finest sense, and to whom we are grateful for the preparation of this expressive audio montage.

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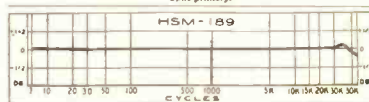
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S-148A	P.P. KT-66, 807, etc. triodes 10000 C.T.	4-8-16	25



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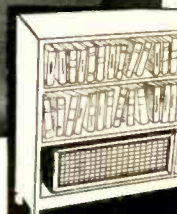


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WEIGHTED TURNTABLE:

RC-80 turntable is heavily weighted to give flywheel action so that any variations in the drive motor are not reflected in record reproduction. No turntable rumble.

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Speed maintained throughout a wide variation in line voltage. There is no appreciable speed variation on operating unit "cold" with a full load or "hot" with one record, regardless of weight, thickness or diameter of records.

IMPORTANT!

Only a 4-pole motor can assure no hum when used with sensitive magnetic pickups.

TWO INTERCHANGEABLE SPINDLES:

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Perfectly meshed to insure constant smooth action and years of service.

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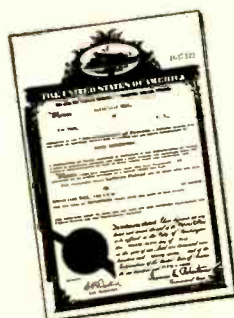
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AUDIO PATENTS

RICHARD H. DORF*

To the voluminous lore of audio phase splitters we add this month another note, this time not in the form of a new type of splitter, but of a slight circuit change which tends to get rid of hum. The hum problem is less than severe in the highly developed amplifiers which most *Æ* readers seem to want and build, but there is still a hard core of the electronic engineering profession working with what we can only name "department-store audio." Department-store audio (consisting of radio-phonographs and combination TV-radio-phonograph sets, built for and sold to the ordinary, unsuspecting consumer to whom high-quality audio is mentally on a par with space travel) occasionally does indulge in push-pull amplifier circuitry. The push-pull amplifier is usually combined with a 50-cent output transformer and nothing resembling an adequate speaker enclosure, so its chief function is to provide advertising copy.

There are a few quality-omission sins which keep designers out of heaven in department-store audio, all of them being of the sort to which a d-s consumer can point out with no mental exercise. One, for instance, is rattle, as from a loose speaker cone. Another is excessive hum; for while no product of d-s-a is complete without a treble suppressor, who would dare take away that delightful tom-tom effect by including a bass control! Coupled with hum's obvious character is the usual desire for a cost saving by using resistors in place of chokes in the power-supply filter.

Wen Yuan Pan has apparently thought enough of the problem to come up with a small circuit revision in a standard phase splitter, which he claims can reduce hum level by as much as 10 to 1. His patent is No. 2,626,321, and it is assigned to RCA.

* 255 W. 84th St., New York 24, N. Y.

Figure 1 is the circuit of a very old (1927) type of phase splitter. Signal is fed to V_1 , the first half of the splitter. Its plate load is R_1 and the following grid resistor is the series combination of R_2 - R_3 . From the latter a voltage is tapped and fed to the grid of V_2 , as a result of which V_2 has an output opposite in phase to that of V_1 and (if the tap between R_2 and R_3 is chosen right) equal in amplitude.

The push-pull stage is balanced and is therefore relatively insensitive to hum. Disregarding hum originating from the signal source fed to the grid of V_1 , hum from the power supply appears at the grid of V_1 , its amplitude depending on the voltage-divider action of R_1 and R_2 - R_3 . If the splitter circuit is symmetrical the same hum appears on the grid of V_2 . Since these two are in phase, they cancel in the output stage.

However, a part of the hum appearing on the grid of V_1 is amplified by V_1 and appears at the grid of V_2 out of phase; the algebraic addition of the component arriving at V_2 through R_3 and the amplified output of V_1 just mentioned gives a resultant which is in phase with the net hum at V_2 , but of smaller value. The difference is, of course, amplified by the final stage and appears at the output.

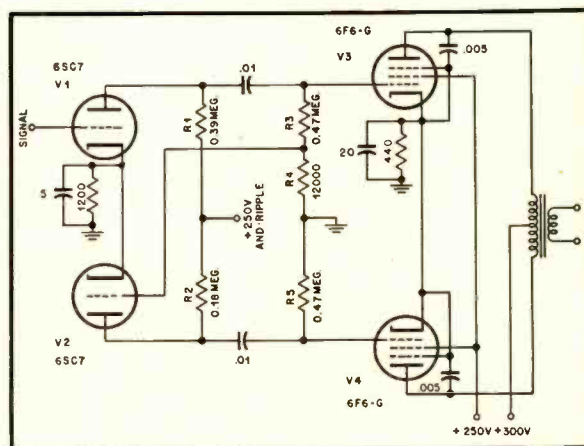
The inventor reasons that if the hum component at the grid of V_2 is simply increased in amplitude, the two grids will again be balanced for the ripple and it will cancel. This he does by making R_3 smaller in value than R_1 . In this way, the voltage divider R_2 - R_3 from power supply to V_2 grid has a larger output leg (R_3) than its counterpart, R_1 - R_2 - R_3 .

The values given are for a typical circuit designed by the inventor.

Tone control circuits

Audio equalizer circuits are always useful to know about and the ones diagrammed in

Fig. 1



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300.	4.80
400.	5.60

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Frequency (Mc)	Attenuation per 100 ft
100.	2.10
200.	3.30
300.	4.10
400.	4.50

APTITUDE RATING No. 8238

Frequency (Mc)	Attenuation per 100 ft
100.	1.90
200.	2.85
300.	3.60
400.	4.35

APTITUDE RATING No. 8239

Frequency (Mc)	Attenuation per 100 ft
100.	3.10
200.	4.40
300.	5.70
400.	6.70

APTITUDE RATING No. 8241

Frequency (Mc)	Attenuation per 100 ft
100.	3.75
200.	5.60
300.	7.10
400.	8.30

Frequency (Mc)	Attenuation per 100 ft
100.	3.75
200.	5.60
300.	7.10
400.	8.30



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ing response for this circuit is the upper one of Fig. 4.

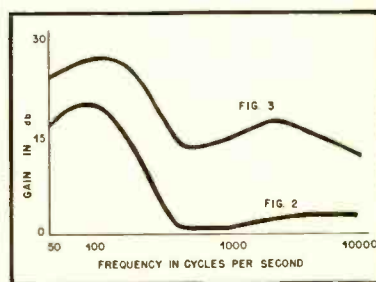


Fig. 4

Too Many Patents?

In looking over a large number of patents, especially those covering circuits, the writer is often moved to wonder on what basis the patents were granted. Even laying aside for the moment the patents covering obviously impractical circuits, it appears that a large percentage of grants cover circuits which do not represent what a reasonable engineer would probably call anything but routinely ingenious practice of the profession of engineering. This is, of course, a legal question of interpretation of the letter and spirit of patent law, and it has been discussed voluminously by people who are qualified. But even speaking as a non-legally-qualified engineer, it seems that the patent law must have been promulgated to protect those with new ideas representing originality of thought and concept, not those who have used existing knowledge and procedure to juggle components into slightly different form.

The effect of what appears to be rather indiscriminate granting of letters patent would be, without other checks, to deprive engineers in general of the right to use many circuits which they would design as a matter of routine, rather than to secure to those of inventive and original mind the results of their particular geniuses.

The lack of discrimination in the Patent Office is the more surprising in view of the fact that the examiners take every possible precaution to comply with that part of the law which prohibits granting of patents where there has been anticipation. It rarely takes less than two years—and usually much longer—to obtain a patent; and in the course of it the examiner almost always interposes objections on the basis of prior art. Why, then, is not that provision of the law covering what is patentable more often applied?

Part of the answer is probably that examiners do not feel that they ought to sit in judgment of this kind. Another part is inability to examine as closely as desirable because of the tremendous volume of applications. But in any case, we fortunately have the courts, which every day sit in patent cases and invalidate a very large number of patents. The hitch is that sometimes mere threat of an infringement suit is enough to cause a defendant of less substantial resources than the patent-holding company to validate the patent in effect by ceasing to use it lest he lose his shirt in expensive legal proceedings.

On the bright side, anyway, is the fact that patent specifications provide an interesting and useful source of information for the engineering public. Twenty-five cents will bring you any patent; address your request to The Commissioner of Patents, Washington 25, D. C.

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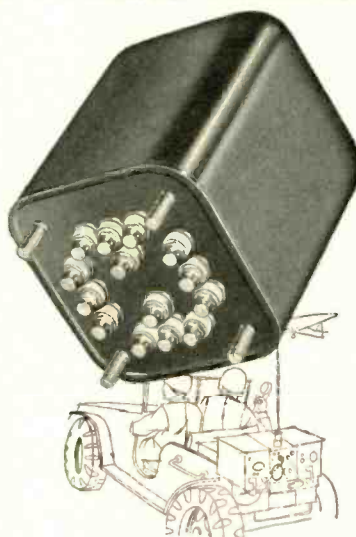


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PMS-70	MS-90026	200-100-0-100-200	70	385	6.3/5	2	6.3	3	4
PMS-70A	MS-90027	325-0-325	70	260	6.3/5	2	6.3	4	5
PMS-150	MS-90028	325-0-325	150	245	6.3	5	5	3	7½
PMS-175	MS-90029	400-0-400	175	318	5	3	6.3	8	10
PMS-250	MS-90030	450-0-450	250	345	5	3	6.3	8	13
PMS-350	MS-90031	350-0-350	250	255					7½
PMS-550	MS-90032	550-0-550	250	419					11
PMS-800	MS-90036	800-0-800	250	640					16½

FILAMENT TRANSFORMERS (PRIMARY:—105/115/125 V.—Frequency 54-66 cycles)

CATALOG NUMBER	MIL-T-27 PART NO.	SECONDARY Volts	SECONDARY Amps	INSULATION VOLTS RMS	WT. LBS.
FMS-23	MS-90016	2.5	3.0	2500	1½
FMS-210	MS-90017	2.5	10	2500	2½
FMS-53	MS-90018	5.0	3.0	2500	1¾
FMS-510	MS-90019	5.0	10	2500	4
FMS-62	MS-90020	6.3	2.0	2500	1¾
FMS-65	MS-90021	6.3	5.0	2500	2¾
FMS-610	MS-90022	6.3 CT	10	2500	5
FMS-620	MS-90023	6.3	20	2500	8
FMS-210H	MS-90024	2.5	10	10000	4¾
FMS-510H	MS-90025	5.0	10	10000	7

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LETTERS

Merit vs. Demerit

SIR:

The proposed Figure of Merit for output tubes has much value for the circuit engineer. I find that some realistic comparison of the many types available is important for preliminary design considerations.

The items your equation includes give advantage to the pentode types. For most audio considerations, unless special circuits are used, the value of the triode with its inherently lower impedance, is masked by the other factors. I would suggest that the effect of plate resistance should be included. One method would be to consider twice the tube resistance in parallel with the load resistance. This would make factors for 2A3 of 5.0 and 11.3, while the 6V6 pentode factors would be 4.05 and 3.67 instead of the lower values your equation gives.

The revised merit equation would be as follows:

$$F. M. = \frac{P_o (100 - D) (R_l - 2R_p)}{2 R_l R_p E_g}$$

For some few applications it is probable that your figure may be more accurate. However, since pentodes will need negative feedback to obtain triode characteristics, the suggested revision should take this into account.

G. B. HOUCK, JR.
63 Bedford Road,
Pleasantville, N. Y.

SIR:

I am indebted to Mr. Houck for his suggested revision in my Figure of Merit which takes the effect of plate resistance into account, making a comparison which includes both pentodes and triodes more impartial.

On the other hand, I feel compelled to disagree with the points made by Mr. Garner (Æ, May 1953). It was clearly stated that the application was to high-quality home amplifiers. Since the cost of power tubes is a small part of the expense of a home amplifier and since electrical power is cheap, the omission of these factors seems reasonable. Most Golden Ears of my acquaintance would be happy to provide 1.6 amps in their living rooms if they felt the quality of reproduction were really improved by so doing.

The proposed incorporation of the distortion percentage directly in the denominator would be silly, since the barely—if at all—perceptible difference between, say, 0.1 and 0.5 per cent distortion would result in a five-to-one difference and swamp out the other much more important factors.

WARREN G. BENDER,
62 Park Street,
Tenafly, N. J.

High Fidelity

SIR:

I am not in complete agreement with one of the statements made by Mr. Dickey in his essay "High Fidelity," (Æ, April 1953).

In this essay, Mr. Dickey states that "... the pitch of a constant-frequency tone varies with amplitude. The artist will perform so as to produce the correct pitch initially, but when the level is changed upon reproduction (the frequency remaining constant), there is a change in pitch."

Certainly it's true that the pitch of a constant-frequency tone will vary with amplitude—but I think this will be true

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FIG. U.S. PAT. OFF.
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BRAND

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Now—enjoy the ultimate in easy handling, in smooth performance on all machines with the all new, all improved "Scotch" Brand "V" slot 7" reel. It's the first truly *functional* plastic reel. 1200 ft. lengths of 111A and the sensational new 120 "High-Output" "Scotch" Brand Magnetic Tape are wound on this new "V" slot 7" reel—splice free.

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- LARGE 2 1/4" HUB. The only reel that accommodates standard lengths of all magnetic tapes and minimizes timing errors. Eliminates tape spillage in rewind.
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- EASIER LABELING. Extra large unobstructed writing and labeling surface for added convenience.


Your electronic parts distributor has it!
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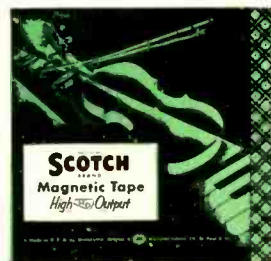
● 111-AP Magnetic Tape also available on the "SCOTCH" Brand professional reel.

Costs no more than ordinary reels

FIG. U.S. PAT. OFF.
SCOTCH Magnetic Tape
BRAND



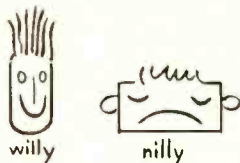
High Output and  TM 3M Co. The term "SCOTCH" and the plaid design are registered trademarks for Sound Recording Tape made in U.S.A. by MINNESOTA MINING & MFG. CO., St. Paul 6, Minn.—also makers of "Scotch" Brand Pressure-Sensitive Tapes, "Underseal" Rubberized Coating, "Scotchlite" Reflective Sheeting, "Safety-Walk" Non-slip Surfacing, "3M" Abrasives, "3M" Adhesives. General Export: 122 E. 42nd St., New York 17, N.Y. In Canada: London, Ont., Can.



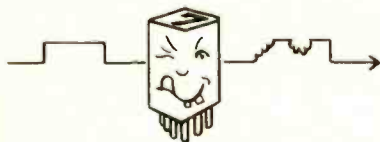
NEW BLOOD IN THE PULSE RACKET

It is gratifying to note that within a month of our attack on relays for the pulse market, a favorite competitor has done the impossible and brought out an impulse relay. It is improbable that our implications impelled him to such an important step, but the impression, though implausible, adds impetus to our plans.

The purpose of a pulse (or impulse) relay is either to make round pulses square or to make little square pulses big. Relays are not usually used to make narrow pulses wide or wide pulses narrow, although some do, willy nilly.



Relays like our Type 7, which eat a couple of milliseconds off a pulse and then bite out a nick in the form of a half-millisecond bounce,



are no better than rumor-mongers as repeaters of information. That new impulse relay certainly beats it all hollow because it operates twenty times as fast, and doesn't bounce.

If our new relay could do that, as well as what it already does, we wouldn't have to advertise for long. To be specific, it is SPDT, and it will operate in about .0006 seconds, transfer taking

as little as .00025 seconds off your pulse.

It never bounces, of course, and will handle substantial contact loads such as a teleprinter for over 100,000,000 operations. It looks like this:



Both these wonderful relays are pretty hard to get. You can have one of ours right away, if you convince us that you need something a lot better than our "7" (if not, that's what you'll get).

Furthermore, you'll have to answer a lot of questions about your gadget and its purpose (how else can we learn about "new frontiers"?). Finally, you'll have to settle for commercial quality and finish; no leak proof, salt proof, fire proof, fungus proof; so far all we've tried is to make it goof proof.

FEATURES OF THE NEW PULSE RELAYS

	SIGMA	COMPETITOR
Operating characteristics	Two coil polarized	Single coil neutral
Contact Arrangement	SPDT	SPST
Contact load and life rating	10 ⁸ @ 60 ma (contacts easily replaced)	5 x 10 ⁶ @ .075 ma
Contact separation	.004"	.0005"
Max. Aperiodic pulse rate	400 cps	1000 cps
Max. following pulse rate	1200 cps	2500 cps
Signal for good operation	+20, -20, +20 ma	40, 0, 40 ma
Coil resistance	150 Ω each	135 Ω
Height and diameter above oval plug	2 1/2" x 1 9/32"	1 21/32" x 1 15/16"

SIGMA INSTRUMENTS, INC.

106 Pearl Street, So. Braintree, Boston 85, Mass.

only if the tone is pure. For example, in one of the standard college physics textbooks (F. A. Saunders: *A Survey of Physics*, pp. 290-291) it is stated that a pure 200-cps tone will appear to drop in pitch if the sound level is increased, but if the tone is not pure this change will not be heard. It is also stated that because of harmonics a complex tone will remain fixed in pitch.

If this information is correct, then the remainder of Mr. Dickey's statement cannot be true. Since orchestral instruments are rich in harmonics, we should therefore expect to have no change in pitch if, for example, a solo violin is recorded and then replayed at a higher sound level.

It may also be of interest to note that this information is in direct contradiction to the comment made by Villchur in a footnote on page 40 of the November 1952 issue of *AE*, in which the author states that the change in pitch with sound intensity "is very much greater with rich tones than with pure tones."

Now the question is, who is right?

A. A. SCHULKE,
Department of Physics,
Washington University,
St. Louis 5, Mo.

(A \$64 question, too, we think. Makes us wonder who the authorities are in this business. Incidentally, the italicized word *violin* was substituted for the word "flute" originally written by Mr. Schulke. The substitution was made because the flute comes most closely among orchestral instruments—to being a pure tone, and might further cloud the issue. Anyway, here's Mr. Villchur's reply. Ed.)

SIR:

I believe Mr. Schulke's point is well taken, and he has caught me in two errors. One is a reversed meaning—the footnote should have read: "This 'normal illusion' is very much greater with *pure* tones than with *rich* tones." The other is that, as in earlier chapters, I have neglected to supply references for such points.

Tests to determine the effect of timbre on the pitch-intensity relationship were conducted by Harvey Fletcher and described in *J. Acous. Soc. Am.* in October, 1934. The change in pitch produced by the variation of intensity was in general only one-fifth as great for complex tones as for pure tones. A direct study of this effect in musical instruments was reported by Lewis and Cowan in "The Influence of Intensity on the Pitch of Violin and 'Cello Tones," *J. Acous. Soc. Am.* in July 1936. Expert musicians were asked to play certain pitch intervals, first very softly and then very loudly. Measurement of the physical frequencies which they produced showed little if any significant compensation for the influence of intensity on pitch.—E.M.V.

COMING EVENTS

July 13-16—MUSIC INDUSTRY TRADE SHOW, Palmer House, Chicago, Ill.
August 19-21—1953 WESCON (Western Electronic Show and Convention), Civic Auditorium, San Francisco, California.
September 1-3—INTERNATIONAL SIGHT AND SOUND EXPOSITION, combined with the CHICAGO AUDIO FAIR, Palmer House, Chicago, Ill.
October 14-17—Fifth Annual Convention of the AUDIO ENGINEERING SOCIETY, and THE AUDIO FAIR, Hotel New Yorker, New York City.



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audiology

W. R. AYRES*

Hum Reduction in Amplifier Development

PARTICULARLY among the exponents of listening tests, noise and signal-to-noise ratio are subject to varied interpretation as regards acceptability. Narrow spikes and random noise, or the so-called hiss, may be quite noticeable over the frequency range in which the ear is sensitive, and audible under no-signal conditions though the effective magnitude is quite small as read on a meter. On the other hand, the ear is rather insensitive at 60 cps, so that by listening tests a sound system might be pronounced hum-free even though a monitoring oscilloscope shows the hum to be materially larger than the hiss. Thus the unqualified meter reading for specification or test is helpful but not conclusive.

In quality equipment as for studio use, hiss magnitude within a few decibels of thermal agitation noise is not uncommon, with hum amplitude roughly equal to the hiss. Using now common techniques and particularly with a type 1620 input tube, this can be accomplished in production with a.c. heater operation and no hum-balancing potentiometers. Often, however, unusual requirements necessitate the design of new or special equipment, and hum reduction may be quite a problem.

When developing audio amplifiers for low hum traceable to a.c. power source, the following considerations (not necessarily listed in the order of their importance) will be found useful. Power supply ripple reduction is not considered here, as it is usually the easiest (though not the cheapest) to accomplish.

1. Bypass the cathode resistor in the stage contributing most greatly to the output hum amplitude. This is usually, but not necessarily, the first stage. In amplifiers of high power output or low gain, the output stage may be the most serious offender.

2. Bias the heater-supply relative to the cathodes of tubes having unbypassed cathode resistors. A positive biasing potential of 15 to 30 volts is recommended, with preferably no more than a few thousand ohms impedance to ground at power-line frequency. One plan, usually satisfactory and requiring no additional components, is connection of the heater winding center-tap to the cathode lead of a cathode-biased power output stage.

3. Keep heater and other power wiring close to the chassis, and keep low-level

high-impedance components and wiring separate therefrom. When lowest possible hum is sought in a stage with high-impedance input, a metal tube with top grid-cap (like type 1620) is usually preferable.

4. Particularly for single-ended tubes (including miniature types), use mica-filled or ceramic sockets rather than those of simple molded plastic material, to reduce leakage across the socket from heater to grid or plate pins.

5. Try d.c. heater operation. Often the heater winding of the first stage may be included as part of the cathode biasing resistance of the power amplifier stage, with adequate circuit bypassing to prevent objectionable signal feedback.

6. To minimize signal lead lengths, use point-to-point rather than terminal board wiring in low-level stages.

7. Use a heavy ground bus (or at least interconnected signal grounds) rather than random chassis grounding, to avoid the so-called ground loops. This is commonly done in high-quality apparatus, though for simplified presentation the schematic diagram may indicate random grounds.

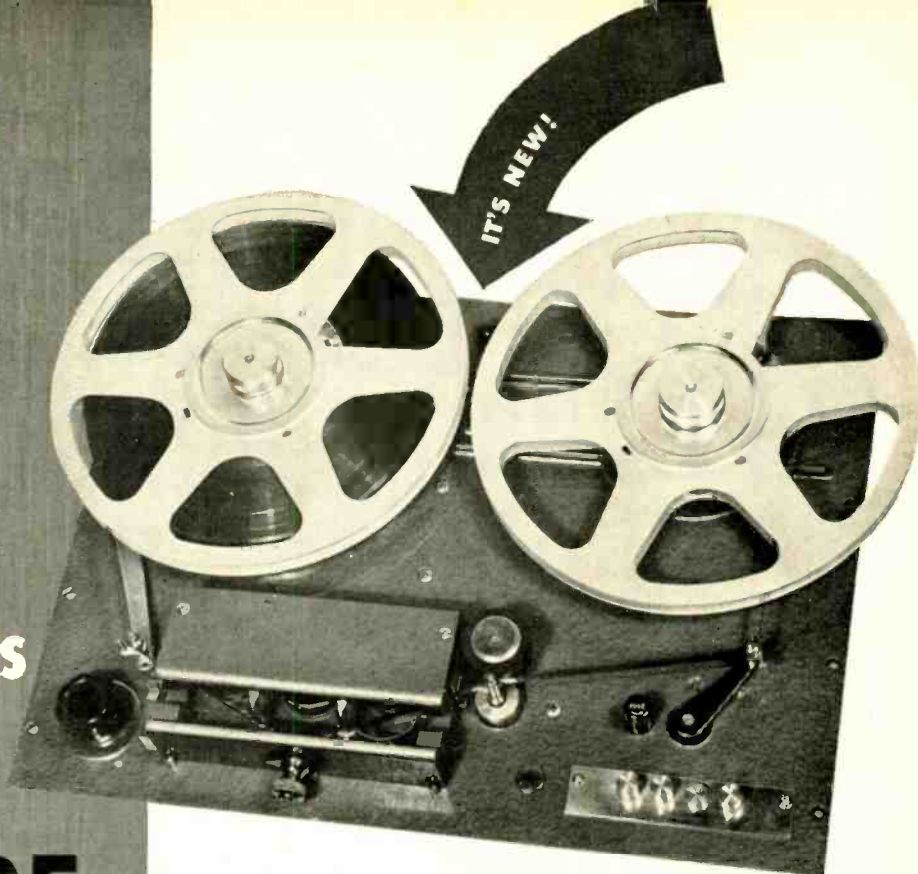
8. Use adequate magnetic shielding at the input transformer, magnetic pickup, tape playback head, etc., and maximum practicable separation between these and power supply components. Objectionable hum may be induced in the output transformer, due to proximity of the power transformer or choke of a choke-input power supply filter. Orient the signal transformers for minimum hum pickup, which usually means positioning the induction-sensitive component so that the axis of its coil is perpendicular to the direction of hum field. Sometimes a hum-bucking winding arrangement may be used to advantage in input transformers, pickup heads, equalizer coils, etc. In this winding plan, coils are divided into pairs, and connected to be series-aiding for circulating magnetic (wanted) fields, but series-opposing for the parallel (unwanted) fields of remote origin. Ordinarily, however, simple shields are more effective and less costly. Nickel alloys such as Mumetal are best in this regard. Most successful shields for small transformers are drawn Mumetal cans (about 0.040 inch wall thickness), hydrogen-annealed after forming. Telescoping cans with non-magnetic separators and close-fitting covers may be used if a single shield will not suffice. A well executed shielding job with two Mumetal cans and copper separator will usually make the

(Continued on page 56)

* 311 West Oakland Ave., Oaklyn 6, New Jersey.

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tape
recorders
in the

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PRESTO introduces a precision-engineered tape recorder with a radical new type of construction!

Featuring a self-contained capstan drive unit, the PRESTO RC-11 provides durability, flexibility and rapid maintenance heretofore unheard of in tape equipment. Motor, fly wheel, capstan shaft, pressure pulley and solenoid are all pre-mounted on a cast aluminum sub-assembly . . . a complete working unit quickly removable for service or replacement.

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The combination of advanced design and engineering in the RC-11 puts ordinary tape recorders in the shade . . . makes this instrument an *investment*, not an expenditure. Ask your PRESTO distributor for full information on this important development in tape recorder design . . . the *all new* RC-11.

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. . . allows a complete flexibility in the manufacture of various types of instruments. By the simple rearrangement of components the RC-11 becomes a high fidelity recorder, a dual track, bi-directional recorder or reproducer or a long-playing reproducer with automatic tape reversal.

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EDITOR'S REPORT

ENGINEERING JOBS

ONE OF THE important problems facing industry in the current years is that of a shortage of engineers in practically all fields. Recent reports indicate that by 1954 there will be over 25,000 new jobs in civilian industry for engineers, but only about half that many new graduates will be available to fill these positions.

At the present time, about one fourth of the graduates are being commissioned in the Armed Forces as a result of their ROTC training, and another fourth become eligible for the draft. Less than ten per cent remain in full-time graduate studies.

According to the American Peoples' Encyclopedia 1953 Yearbook, to which we are indebted for this information, one solution is for industry to use its engineers more efficiently as engineers, and to put non-engineering routine work in the hands of those who are not qualified for the more rigorous engineering work.

The forward-looking young man—or young woman, for that matter—may well see in this statement a solution to his life work, although unless further along with planning, little help to industry would result this year or next. However, there are always more years coming along, and engineering does offer its rewards—both financial and in the satisfaction of doing something important in the scheme of life.

As for the immediate future, there does seem to be considerable merit in the suggestion that engineers be used only on technical engineering work, and that other work should be taken away from the load assigned to the engineers. According to the Yearbook, which states that as much as one third of engineers' work is not technical, the correction of this condition would provide a fifty per cent increase in engineering time. What other method can give immediate returns?

NOISE REDUCTION

A special summer program on noise reduction has been announced by Massachusetts Institute of Technology to cover a two-week period from August 24 to September 4. The course is designed primarily for engineers and scientists who require a working knowledge of means for noise reduction in industrial plants and buildings. The program is to consist of ten lectures supplemented by field trips and round-table discussions, and will cover the following subjects: basic terminology and concepts, measurement of noise, psychological aspects,

room acoustics theory, noise reduction in rooms, transmission of sound through structures, characteristics of noise sources, materials and structures for noise reduction, mufflers and vibration isolators, and machinery and ventilation-system quieting. The special program is under the direction of Professor Leo L. Beranek, who will be assisted by Jordan J. Baruch, Richard H. Bolt, Robert B. Newman, and Walter A. Rosenblith. Living accommodations are available in various units of the MIT dormitory system, and complete information may be obtained from the Office of the Summer Session, M. I. T., Cambridge 39, Massachusetts. If the period of the course happens to coincide with a vacation, this might be a good way to spend it—if you can convince the family.

EXHIBITS, CONVENTIONS, SHOWS

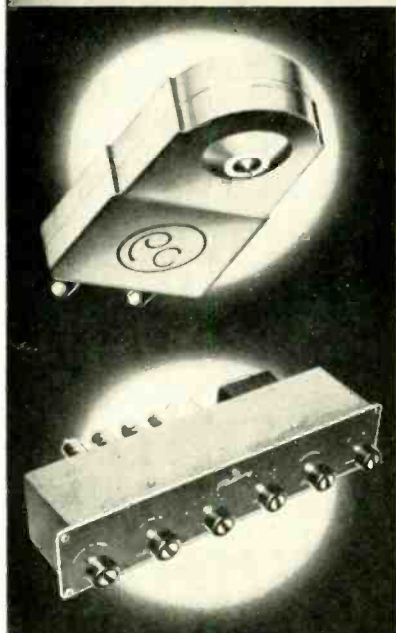
Just returned from the Radio Components Show and the British Industries Fair in London, and just having missed both the NARTB and Acoustical Society meetings in Los Angeles and Philadelphia, and with the Radio Parts Show in Chicago just starting as this is being written, we have now only four important affairs of this type to look forward to in 1953—the Music Trade Show in Chicago in July, the Western Electronic Show and Convention in San Francisco in August, the International Sight and Sound Exposition and the Chicago Audio Fair in Chicago in September, and the big one of the year—The Audio Fair in New York in October. Incidentally, we saw the first public sign of the ISSE&CAF in Paris on the wall of a wine cellar—as a matter of fact, we saw the sign being put there and did nothing about it, except cheer.

The August WESCON show in San Francisco is the only one of those named which has to date put out any advance publicity about its technical sessions—although some of the shows make no claim to technicality. We are pleased to see that the convention in San Francisco plans a few evening sessions—one of which is scheduled to be on audio. This may entice many who cannot attend during the daytime hours, and may serve to bring more attention to audio in all its aspects. Pre-convention interest is being fanned by a number of evening meetings on related subjects some time before the opening of the Convention itself. Among these subjects is a special discussion of magnetic recording apparatus and techniques given for the Federal Court Reporters. This meeting is sponsored by the San Francisco Section of the Audio Engineering Society, and could be very interesting.

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are the choice of audio engineers throughout the world. They are universally acclaimed because of their high output, wide range performance and low distortion. They are used wherever a fine cartridge is required in radio stations, recording studios and for purposes of quality control by leading record manufacturers.

.....

MODEL 410 AUDIO INPUT SYSTEM . . .

is designed to provide a complete audio control center. Model 410 may be used in any high quality playback system. Three input channels are provided—one for magnetic cartridges and 2 "flat" channels for other audio circuits. A 3-position equalizer network is built into the magnetic cartridge channel and provides accurate equalization for LP, AES and 78 rpm recording characteristics. Separate bass and treble controls are also provided. These are of the step-type and permit bass and treble adjustments in 2 db increments. The tone control circuits are intended to compensate for record characteristics and for listener-environment acoustical conditions. They are not intended to compensate for amplifier and/or loudspeaker deficiencies. Model 410 is intended for use with the highest quality professional type playback equipment. The output of the Model 410 is fed from a cathode-follower circuit and will work into any high quality audio or line amplifier having a high impedance input. It may also be used with a transformer for the purpose of feeding a 500 ohm line. Because of its flexibility, low noise and low distortion level, it is ideally suited for bridging and monitoring purposes and for critical listening applications.



THE MODEL 190 ARM . . .

is designed primarily for use with microgroove records. Its design has been recognized by leading audio engineers as that which incorporates all of the desirable tracking characteristics. Analysis has shown that for maximum performance with LP records the vertical mass of the moving arm element must be held to a minimum and further, that the arm must be counterbalanced about the vertical axis. This permits minimum stylus or tracking force and provides maximum record life. The Model 190 Arm embodies these all important features necessary for proper microgroove record playback.



MODEL 230H EQUALIZER-PREAMPLIFIER . . .

is unique in its accuracy of equalization and frequency response. The intermodulation distortion is .2 per cent at normal output level. It is intended for use with high quality amplifiers having gain and tone controls. When used with the Pickering Model 132E Record Compensator the 230H is ideal for radio station and recording studio use and for applications requiring accurate low noise and distortion free playback.



MODEL 132E RECORD COMPENSATOR . . .

is designed to be used in conjunction with a magnetic cartridge preamplifier such as the Pickering 230H or any preamplifier which provides 6 db per octave bass boost. Six playback positions are incorporated:

- 1—European 78 rpm Records
- 2—Victor 45 rpm and Decca 78 rpm Records
- 3—No high frequency roll-off, 500 cycle turnover
- 4—All Capitol Records, new Victor 33 1/2, Audio Engineering Society Curve
- 5—Columbia, London and most LP Records
- 6—To remove the hiss from old noisy records

Precision elements are used in its construction to give accurate compensation. The 132E is inherently a low distortion R-C device.

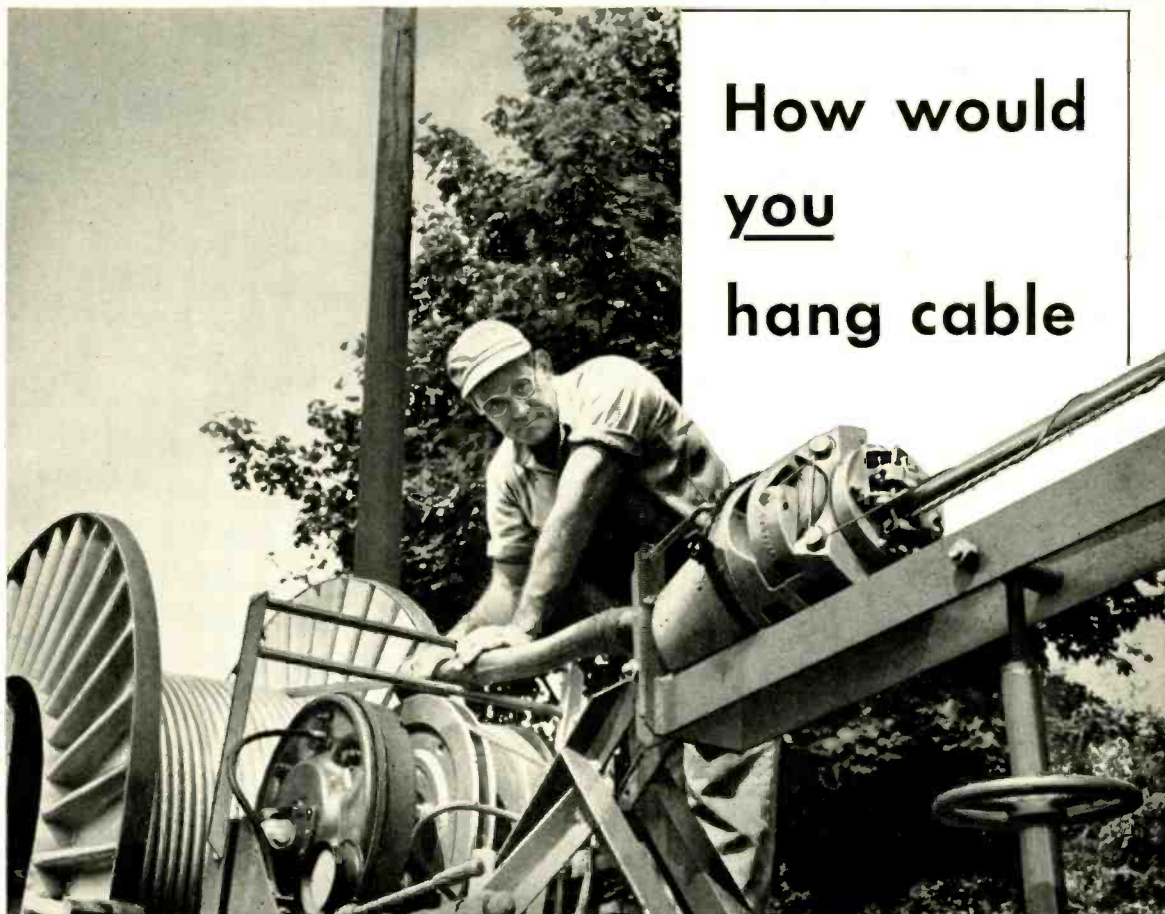
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...by the
mile?

It is a job your telephone company faces every day. Thousands of miles of cable go up each year—all secured to steel strand running from pole to pole. The best way to secure cable is to *lash* it to the strand with a spiral binding of wire.

One way to do this is to raise cable and strand separately, then lash them together by a rotating machine pulled along by workmen on the ground. This produces a strong, tight support for the cable. But each pole has to be climbed as many as four times. So Bell Laboratories engineers devised an easier way.

Now, lashing can be done *on the ground* so that cable, strand and lashing wire may be pulled into position as a complete assembly. Usually workmen need make only two trips up each pole.

For telephone users, the new way means that cable can be installed faster, while costs are kept down. It shows again how work at Bell Telephone Laboratories improves each part of your telephone system.

Bell Telephone
Laboratories



IMPROVING TELEPHONE SERVICE FOR
AMERICA PROVIDES CAREERS FOR CREATIVE
MEN IN MECHANICAL ENGINEERING

The Lateral Mechanical Impedance of Phonograph Pickups

J. G. WOODWARD* AND J. B. HALTER*

Part 1. A discussion of one of the characteristics of phonograph pickups which affects frequency response, as well as record and stylus wear. The authors analyze various types, with explanations of the results.

THE LATERAL MECHANICAL IMPEDANCE of a phonograph pickup has come to be regarded as one of its most important characteristics. This is as it should be since the lateral impedance at the pickup stylus determines the tracking capability of the pickup and, consequently, the record and stylus wear and the tracing distortion. The stylus of a pickup having a large value of lateral impedance will not follow the modulation of the record groove unless an excessively large vertical stylus force is used. The combination of large vertical force and high lateral impedance results in rapid wear of both the stylus and the record.

Notable improvements have been made in pickups during recent years through the reduction of the lateral impedance. An early and strong stimulus for such improvement was the need for pickups which would permit instantaneous playback of lacquer transcriptions without serious wear of the record. Once such pickups had been developed, the design techniques were applied to pickups for home reproducers, and the use of commercial vinylite pressings—with the attendant reduction in record noise became practical. Still further reduction of the mechanical impedance has made possible the use of small-radius styli and the microgroove records which have achieved considerable popularity. Many of these remarks apply also to the vertical impedance at the stylus, since the pinch effect requires the stylus to

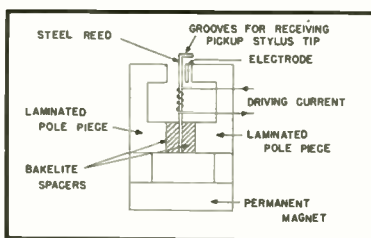


Fig. 1. Diagram of electromagnetic vibrator used to drive a pickup stylus in a controlled manner.

vibrate in a vertical as well as a horizontal plane for acceptable phonograph reproduction. However, the following discussion will be restricted to the consideration of the lateral impedance.

Some phonograph pickups are characterized as having a high compliance. While a large value of lateral compliance, i.e., a low impedance, is undeniably desirable, such a characterization does not tell the whole story, for in some frequency ranges a pickup may exhibit a mass reactance of significant magnitude. Insofar as the adverse effects of too large a mechanical impedance are concerned, a large mass reactance may be just as troublesome as a stiffness reactance of equal magnitude. It is apparent that a complete characterization of a pickup requires the measurement of the mechanical impedance over a wide range of frequencies—preferably over the entire audio-frequency range.

While the desirability of a complete knowledge of the mechanical impedance

of a pickup has been recognized for some time, the actual measurement of mechanical impedance has been and continues to be a difficult matter. Various investigators have constructed devices¹⁻⁴ for the measurement of pickup mechanical impedance, but these have generally been used only within a relatively narrow range of lower audio frequencies. By using the apparatus and techniques to be described in the following section we have been able to measure the lateral impedance of pickups throughout the range between 30 and 10,000 cps. Since the complex impedance was measured, the results may be expressed in terms of mechanical resistance and reactance.

Experimental Method

Since a more detailed presentation of the theory of operation and of the construction of the apparatus has been given elsewhere,⁵ we shall confine our description here to the basic principles necessary for an understanding of the method. The experimental technique is based on the use of a set of four electromagnetic vibrators. The construction of the vibrators is illustrated in Fig. 1. A flat, steel reed .010 in. thick is the armature of a balanced electromagnetic driving system. The upper end of the reed is bent over to provide a small platform in which V grooves have been cut. The stylus of a pickup being tested is set in one of the grooves. When an alternating current passes through the coil of the

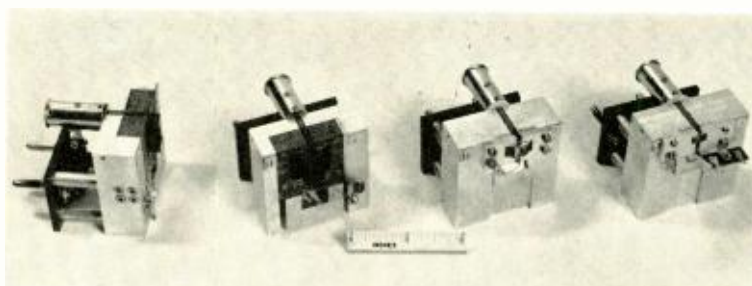


Fig. 2. External appearance of the four vibrators used to cover the entire frequency spectrum under observation.

¹ A. M. Wiggins, "Mechanical impedance bridge," *J. Acous. Soc. Am.*, 15, 50-53; July, 1943.

² B. B. Bauer, "Measurement of mechanical compliance and damping of phonograph pickups," *J. Acous. Soc. Am.*, 19, 319-321; March, 1947.

³ H. A. Pearson, R. W. Carlisle and H. Cravis, "Vibrators for measurement of response and compliance of phonograph pickups," *J. Acous. Soc. Am.*, 20, 830-833; Nov. 1948.

⁴ A. M. Wiggins, "Compliance meter for pickups," *Electronics*, 22, 94/95; Oct. 1949.

⁵ J. G. Woodward and J. B. Halter, "The measurement of the lateral mechanical impedance of phonograph pickups," *J. Acous. Soc. Am.*, 25; March 1953.

vibrator, the reed is set into flexural vibration and the pickup stylus is forced to vibrate laterally at the frequency of the driving current.

A small capacitance-pickup electrode is situated near the upper end of the reed and is used to measure the motion of the reed. The alternating voltage generated at the electrode has the frequency and phase of the reed vibration and has a magnitude proportional to the amplitude of the vibration. When the reed has no mechanical load and the driving current is held constant, the electrode voltage has a magnitude, $|e_0|$, and a phase angle, ϕ_0 . When a phonograph pickup is in the test position the reed motion is altered in a manner depending on the pickup mechanical impedance, and the electrode voltage has a magnitude, $|e|$, and a phase angle, ϕ . Phase angles are measured relative to the driving current in every instance. It can be shown⁵ that the mechanical impedance, Z_{ML} , of the pickup, referred to the stylus tip, is given in terms of the electrical measurements by

$$Z_{ML} = Z_{M0} \left(\frac{|e_0|}{|e|} / (\phi - \phi_0) - 1 \right) \quad (1)$$

Z_{M0} is the complex mechanical impedance of the vibrating reed, itself. This quantity, which must be known at each frequency, is established for each reed by a calibration procedure using

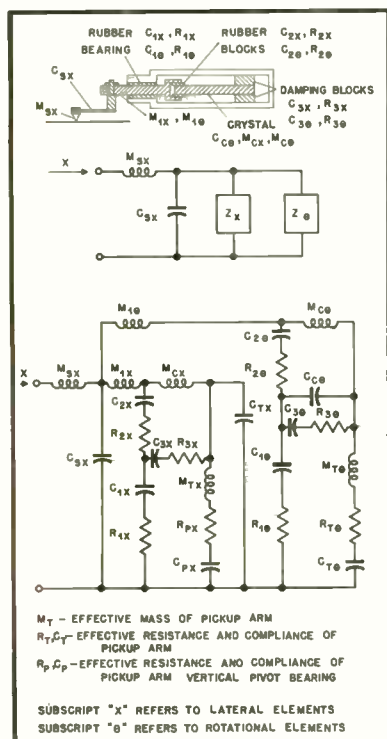


Fig. 4. (Top) Diagram of cross section of pickup used to obtain measurements of Fig. 3. (center) Representation of mechanical system of the same pickup, and (bottom) its complete equivalent circuit.

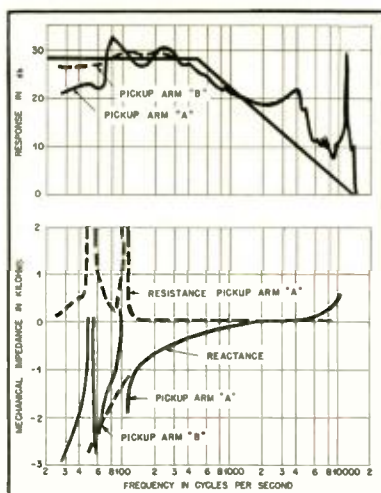


Fig. 3. Typical measurements obtained from observations on a modern microgroove crystal pickup, using the vibrators of Fig. 2 as the driving elements.

loads having known mechanical impedances.

The procedure for measuring the mechanical impedance of a pickup is the following. The pickup stylus is carefully seated in one of the grooves on the reed platform and $|e|$ and ϕ are measured at each frequency of interest, using a vacuum-tube voltmeter and a phase meter for this purpose. Then the pickup is removed from the vibrator and $|e_0|$ and ϕ_0 are measured at each frequency. These measured quantities are substituted in Eq. (1) together with the appropriate values of Z_{M0} , and are thus used to compute the unknown impedance, Z_{ML} , of the pickup. The impedance computed in this way may be expressed either as magnitude and phase angle or as mechanical resistance and reactance, the choice of form being one of convenience or of personal preference.

Since the pickup is always mounted in some sort of pickup arm during the impedance measurement, the computed impedance is not, strictly speaking, that of the pickup, but is rather the impedance of the pickup in conjunction with the particular arm used. This is an advantage since the mechanical impedance of a complete pickup-pickup arm assembly as it would be used in a phonograph system may be studied. When it is desired to measure the impedance of the pickup alone, it may be mounted in a specially designed arm which does not contribute to the mechanical impedance in the frequency range of the measurements.

Each of the four vibrators which constitute the set previously mentioned has a construction similar to that shown in Fig. 1. The vibrators differ only in scale to permit their use in different frequency ranges. Thus, the lowest-frequency vibrator is used between 30 and 600 cps. The highest-frequency vibrator is used between 500 and 10,000 cps. The intermediate vibrators are often not neces-

sary, but are sometimes used to obtain a check on measurements made with the other two vibrators.

The vibrators are mounted on dural blocks fitted with plug-in connectors to permit a rapid and easy interchange of vibrators during a test. The four vibrators are shown in Fig. 2.

Typical Result

The mechanical impedance has been measured for a number of pickups of various types. The measured impedance of a crystal microgroove pickup is shown in the lower part of Fig. 3. Measurements were made with the pickup mounted on two different pickup arms. Pickup arm "A" was the arm supplied with a record player in which the pickup was customarily used. Pickup arm "B" was a special laboratory model. The impedance data are plotted as resistance and reactance in mechanical kilohms. Resistance values are, of course, always positive. Reactance values may be either positive or negative. A positive reactance means that the effective impedance at the stylus tip is a mass. A negative reactance means that the effective impedance at the stylus tip is a compliance.

The response-frequency characteristics for the pickup mounted on the two arms are shown in the upper part of Fig. 3. This characteristic was obtained by means of a pickup calibrator.⁶ During a test the calibrator forces the pickup stylus to vibrate laterally with an accurately known and controllable amplitude and at any desired frequency within the audio range, thus permitting rapid and convenient measurements of the pickup response. The stylus is driven at constant amplitude below and constant velocity above 500 cps with a smooth transition in the crossover region. An idealized response of a crystal

⁶J. G. Woodward, "A feedback-controlled calibrator for phonograph pickups," *RCA Review* 11, 301-309; June, 1950.

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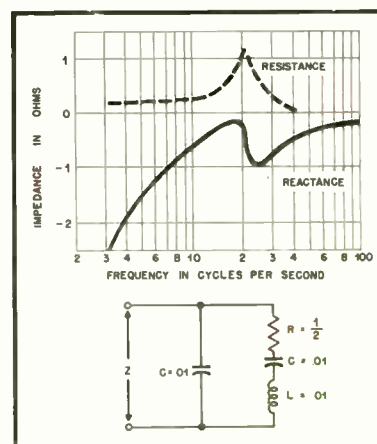


Fig. 5. The curves at the top show the resistance and reactance of a typical mechanical resonant circuit shown in equivalent form in the diagram at the bottom.

Simplified Push-Pull Theory

JULIUS POSTAL*

Part 2. Continuing the discussion of push-pull operation and why second-harmonic distortion is reduced or cancelled completely whereas third-harmonic distortion is not affected.

FUNDAMENTAL FUNCTIONING of the push-pull output stage was discussed in Part 1 of this paper last month, and the voltage relations obtaining in the two tube circuits were shown to produce two equal and opposite signals of increased amplitude when the grids were fed with signals of equal amplitude and opposite phase.

Up to this point, this discussion has given us no indication as to why such a stage cancels out second-harmonic distortion which is generated within the stage itself. The reasons for this will become apparent as we examine what happens when we apply to the push-pull grids a pair of signals which are identical in frequency, waveform, and amplitude, and of the same phase.

Using the push-pull circuit as before, suppose we apply a pair of identical in-phase sine-waves, each having an amplitude of 1 volt, to the two grids. This is the situation set forth in Fig. 10.

At 0 deg. of the input signal to each tube (Fig. 11), the voltage pattern will be that of the now familiar quiescent state.

At 90 deg., the fact that the signal at each grid rises by 1 volt brings about a 14 volt fall in the voltage at each plate. This is shown in Fig. 12. But what does our zero-center voltmeter indicate? It indicates nothing. The needle does not even budge. Why? Since, with respect to ground, the voltage on both plates have moved downward in unison, they are both at the same potential with respect to ground. In short, there is no difference of potential across them. Since there is also no difference of potential across the phones, no current flows through them.

At 180 deg., the mid-point of both input cycles, the voltage pattern is as given in Fig. 13.

At 270 deg., both input waves are at their negative peaks. Both control grids

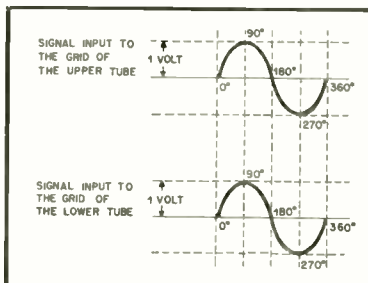


Fig. 10. Two identical in-phase waves, each having the same amplitude, are applied to the grids of the push-pull stage.

have become negative by 1 volt and both plates have gone up by 14 volts to 214 volts. (Fig. 14) Once more, we must face the fact that no difference of potential exists between the two plates.

At 360 deg., the tail-end of both input cycles, Fig. 15 applies.

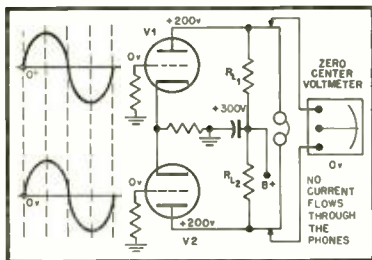


Fig. 11. Two identical signals are applied, with the relations shown for the 0-deg. point of the cycle.

The conclusion to be drawn from all this is that when a pair of equal and in-phase signals is applied to the grids of a balanced push-pull stage, both plates rise and fall in unison.

No matter what point in the input signal cycle we choose, and regardless of what the voltage across each plate and ground happens to be at any particular instant, both plates are always at the same potential with respect to ground.

Therefore, there is absolutely no difference of potential at any time between the two plates themselves. The voltmeter between the plates reads zero voltage and no current whatever flows in the earphones. The foregoing is summarized in Table II.

In short, if a pair of equal, in-phase signals are fed to the control grids of a balanced push-pull stage, the voltage at each plate will swing with respect to ground, but there will be no volt-

age swing between the two plates and therefore no output voltage across the plates.

The same applies to any signal—hum, or other disturbance—which reaches both of the push-pull tubes in-phase, whether it arrives via the control grid circuit or from the power supply via the plate circuit.

Over-biased Operation

We shall now try to prove graphically that when we deliberately operate a push-pull amplifier in such a way that the bias on each of the push-pull tubes is greater than Class A bias (as in class AB₁ or class AB₂), we are, in effect, guaranteeing that on large signals (i.e., signals large enough to swing each tube off the straight-line portion of its characteristic and onto the curved portion) a greater or lesser amount of second-harmonic energy will be generated in each one of the push-pull tubes. In each case, this second harmonic component will be added vectorially to the fundamental.

A scope (preferably one with a balanced input circuit) or a harmonic analyzer (if one happens to be available) will show that this second harmonic energy is present between each push-pull plate and ground or between each push-pull plate and the B+ connection point.⁴

On the other hand, if the indicating instrument is connected across the two push-pull plates, there will be no sign of a second harmonic.

If the earphones are connected from either plate to ground or from either plate to the center-tap of the transformer

⁴ The B+ point is practically at a.c. ground potential—to all but the lowest audio frequencies—because of the output filter capacitor of the power supply. This capacitor is usually connected between the B+ point and ground.

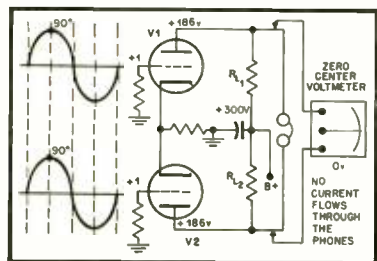


Fig. 12. Two in-phase signals at 90 deg. Note that the voltmeter indicates zero potential difference across the two plates.

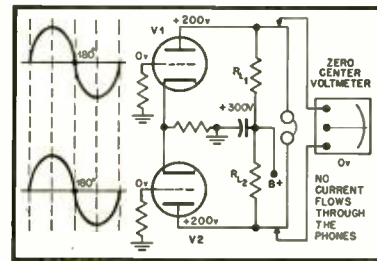


Fig. 13. When the two signals are at 180 deg. the situation is the same as during the quiescent state.

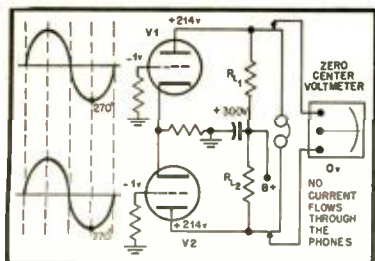


Fig. 14. At 270 deg. the voltage at each plate has increased by the same amount, but there is still no difference of potential between the plates. The pointer of the meter remains stationary and no current flows through the phones.

primary, the current flowing in the phones will immediately show evidence of a second harmonic. And the latter may be of appreciable magnitude.

But if the phones are connected *between* the two plates and if the stage is *perfectly* balanced, no second harmonic energy will flow in the phones.

Since hardly any push-pull stage is *perfectly* balanced in practice, the second-harmonic component will never be completely absent in the final output; it will tend generally to be rather small in amplitude, however, even under practical operating conditions.

A strong fundamental will be present regardless of whether the output voltage is taken off single-ended or push-pull. The second harmonic energy which

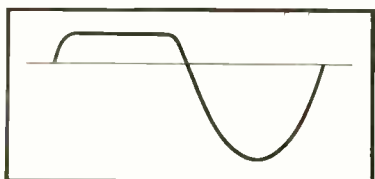


Fig. 16. Output waveform of a stage which is operating non-linearly and into which a pure sine wave was originally fed. This is a distorted or complex wave.

has been generated in each half of the push-pull stage will not be noted if the output signal is taken off between one push-pull plate and the other.

Graphical Analysis

Why this happens can be explained very neatly by Fourier analysis. Let us see, however, what can be done *without* mathematics—by simple graphical analysis:

First, suppose we fix firmly in mind the well known fact that the only waveform consisting of just one single frequency and no other is a pure sine wave.

Any time a pure sine wave is fed into an amplifier and comes out altered in any way, it can be shown that *new frequencies not originally present in the input signal have been added to it during its passage through the amplifier.* The same applies whenever we declare that a sine wave has undergone distortion; we are saying, in effect, that new frequency components have been added to it.

By definition, a sine wave to which other frequency components have been

added, is considered a "complex" wave.

Assume now that we are feeding a pure sine wave into an amplifier and that an oscilloscope shows the output wave-shape to be the "distorted" or complex wave of Fig. 16.

This type of distortion—namely, the flattening of one half-cycle and the elongation of the other—is quite common when a stage or a series of stages is operating non-linearly.

More specifically, such distortion occurs when for some reason, like incorrect bias, the operating point of a tube has been shifted away from the center of the straight-line portion of its characteristic and, at the same time, the strength of the applied signal is great enough to swing the tube on to one of the curved or non-linear portions of the characteristic.

How this distortion—or change in the original wave shape—comes about can be shown graphically by simple algebraic addition.

Figure 17 shows the pair of waveforms which are to be added. The fundamental is a sine wave of frequency f . The shorter waveform, $2f$, has twice the frequency of the fundamental and is therefore its second harmonic. The amplitude of the second harmonic shown here is approximately 20 per cent that of the fundamental. If the phase relationship of these two waves is that shown in Fig. 17, we can expect them to add vectorially as depicted in Fig. 18. The resultant is the waveform drawn in dotted line. It will have a more or less flattened positive half cycle and an elongated negative half cycle. When the amplitude of the second harmonic with respect to the fundamental exceeds a value of approximately 20 per cent, the resultant will tend to develop a dip or valley in that half cycle which here appears flattened.

It should be noted that whenever a stage is operating nonlinearly—i.e., generating second and other even-order harmonic distortion—its plate current will show evidence of a so-called "d.c. component" which is not present during linear amplification.

This d.c. component (also known as the steady or rectified component, depending on the particular nomenclature used) is omitted in the accompanying waveform drawings for the simple reason

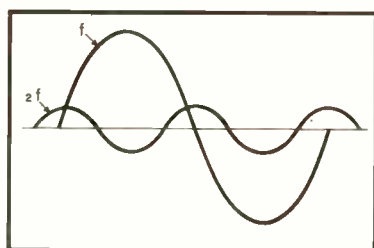


Fig. 17. Two sine-wave components comprising the complex wave of Fig. 16. The signals shown are the fundamental, f , and the second harmonic, $2f$, which has an amplitude approximately 20 per cent of the fundamental.

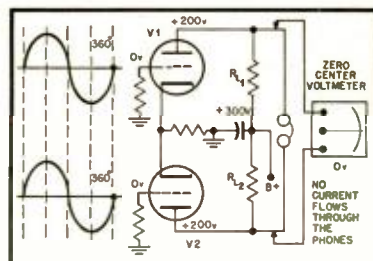


Fig. 15. At 360 deg. the voltage picture is the same as during the quiescent state. At no time during the cycle has the meter registered any potential difference, nor has any current flowed through the phones.

son that these diagrams are predicated on the use of an ordinary oscilloscope—that is, one which is not direct-coupled. Such an oscilloscope will *not* pass the d.c. component. (For that matter, neither will any R-C coupled amplifier or any interstage or output transformer.)

A complete treatment of the d.c. component is outside the scope of this discussion. Suffice to say that the d.c. components which arise in the two halves of a balanced push-pull stage that is operating nonlinearly are always of equal magnitude and in the same direction, at any given moment, with respect to the quiescent-state plate-current axis; therefore, they produce no difference of potential at *any* time across the push-pull plates. Although these d.c. components are present in the *series* current of the power supply, they do not appear in the output signal which is taken off *across* the two pushpull plates.

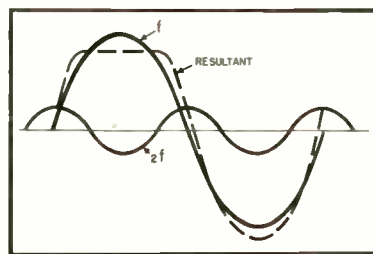


Fig. 18. Vectorial addition of the fundamental and its second harmonic. The dotted line is the resultant.

If the distorted output waveform in Fig. 16 (one flattened half cycle and one elongated half cycle) is seen on an oscilloscope connected across the *upper* plate of our push-pull stage and ground or the center-tap, we may also expect to find the same kind of distorted signal across the *lower* plate and ground, except that there will be a 180-deg. phase difference. (Fig. 19) The complex wave present between the lower plate and ground or CT can also be shown to be made up of a fundamental and a second harmonic in the phase relationship shown in Fig. 20. (Note that it is once again equal to about 20 per cent of the fundamental.) Vectorial addition of the

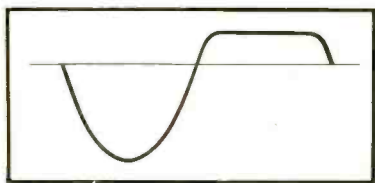


Fig. 19. Waveform between the lower push-pull plate and ground when the distorted wave of Fig. 16 appears at the upper plate.

two waves is represented in Fig. 21. Once again the dotted line indicates the resultant.

The waveform information for both halves of the push-pull stage is summarized diagrammatically in Fig. 22. Observe that in each case the fundamental frequency components are *out of phase*; they will therefore yield amplified signal output voltage across the push-pull plates and across the headphones, too. This amplified signal will naturally have the same frequency as the fundamental.

Now examine the phase relationship of the second harmonic components of

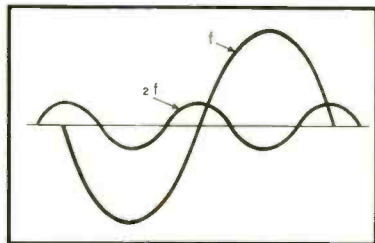


Fig. 20. Vectorial addition of waveforms on the lower plate. Note that while the fundamental is 180 deg. out of phase with that of Fig. 19, the second-harmonic components of the two diagrams are in phase.

the two complex waves. The second harmonics, interestingly enough, are *in-phase*. Moreover, they are *identical* in shape and have exactly the same amplitude. They will therefore "get lost" across the two push-pull plates and there will be no second-harmonic component in the currents flowing through the phones.

What holds true for the second harmonics of the two complex waves will hold equally true for their 4th harmonics, 6th harmonics, 8th harmonics—in fact for any *even-order* frequency components which are added to the fundamental during its passage

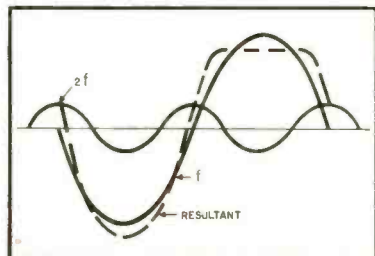


Fig. 21. Complex wave of Fig. 20 can be shown to be made up of fundamental, f , and second harmonic, $2f$, with the amplitude of the latter approximately 20 per cent of the former.

through the push-pull stage. All these even-order components will be *in-phase* and will therefore cancel out and disappear.

In all this reasoning we have assumed that each one of our push-pull tubes has a straight-line portion. The truth of the matter is that this so-called straight-line portion is only an *idealization* of something that does not really exist in reality. Fortunately, however, the departure from genuine linearity is not too serious in most cases.

The gratifying thing about the push-pull connection is that it tends to cancel out or reduce even-order components

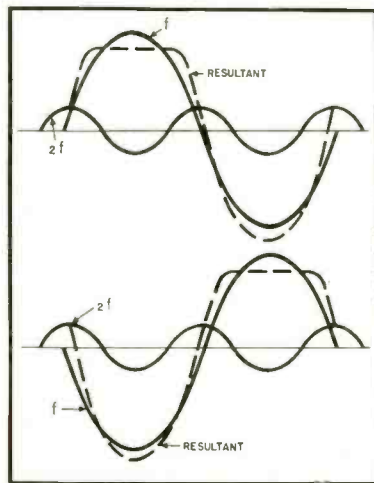


Fig. 22. (A) analyzes the waveform on the upper plate, while (B) shows that on the lower plate. The fundamentals are opposite in polarity, but the second harmonics are in phase, and thus cancel out.

caused not only by deliberate operation on the lower bend of each tube's characteristic, but also those which arise due to the inherent irregularities in this so-called "straight-line portion". The only thing needed in practice for the dramatic reduction of such distortion is the best possible balance attainable in the two halves of the stage.

Odd-order Harmonics

Thus far we have considered what happens to even-order components of the fundamental frequency in a push-pull stage. Let us now turn to the matter of third and other odd-order harmonics.

Assume a vacuum tube biased exactly

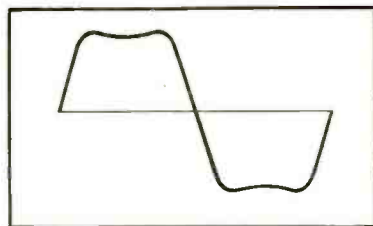


Fig. 23. Typical distorted or complex waveform of over-driven output stage. For symmetrical overloading, the tube must be biased at the center of the straight-line portion of its characteristic.

at the center of the truly straight straight-line portion of an ideal characteristic.

Assume a sine-wave signal of such magnitude as to overload the amplifier and yield the familiar waveform of Fig. 23, which is reminiscent of over-driven amplifiers.

Notice that this present waveform is symmetrical both *above* and *below* the horizontal axis. This can occur only if the tube is biased to operate at the *center* of the straight-line portion of its characteristic. Under such circumstances, if too large a signal is applied, the amplifier overloads, as expected, but—*symmetrically*.

Obviously, the resultant is no longer the pure sine wave with which we began. Rather, it is a *complex* wave consisting of a fundamental plus its third harmonic. The two halves of the waveform—that is, the portions of the waveform which lie on either side of the horizontal axis—are actually "mirror images" of each other. This is typical of *any* wave made up exclusively of

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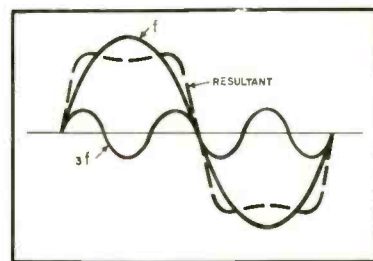


Fig. 24. Graphical representation of the frequency components which comprise the waveform of Fig. 23. The fundamental is f , and its third harmonic is $3f$. The resultant is shown as a dotted line.

TABLE II

Summary of the voltage distribution pattern at five different instants for a pair of in-phase input signals having the same amplitude and waveform.

Phase angle of each input signal	E_{in1} acting at the grid of V_1	E_{in2} acting at the grid of V_2	E_{in1} between the plate of V_1 and ground	E_{in2} between the plate of V_2 and ground	E_{in1} between the two plates	Which plate is positive with respect to the other?	Which way does current flow through the phones?
0°	0 v.	0 v.	+200 v.	+200 v.	0 v.	Neither	No flow
90°	+1 v.	+1 v.	+186 v.	+186 v.	0 v.	Neither	No flow
180°	0 v.	0 v.	+200 v.	+200 v.	0 v.	Neither	No flow
270°	-1 v.	-1 v.	+214 v.	+214 v.	0 v.	Neither	No flow
360°	0 v.	0 v.	+200 v.	+200 v.	0 v.	Neither	No flow

The Pass Band of a Transformer-Coupled Amplifier

J. F. SODARO*

A discussion of the transmission characteristics of an audio transformer and the parameters which affect it. The author reduces calculations to a minimum by the use of an abac.

THE DESIGNER is often confronted with the problem of rapidly determining the pass band of a transformer-coupled amplifier. Straightforward application of the pertinent formulas is a time-consuming process even with the aid of a slide rule. It is the purpose of this article to furnish a rapid, direct-reading calculator for the one- and three-decibel attenuation frequencies. The calculator may also be used to select combinations of circuit parameters which afford a specified band width.

To review quickly the equivalent circuits which are used for this type of calculation, refer to Fig. 1. In these simplified schematics for an output transformer, primary capacitance, hysteresis, and eddy-current resistance are neglected, and the turns ratio is reduced to unity. The leakage reactance at low frequencies and the shunt inductance at high frequencies are disregarded. Secondary circuit parameters are referred to the primary side by using the turns squared factor.¹

The relative gain at low and high frequencies as compared with mid-frequency gain depends upon the values of the effective circuit resistance r' and r'' as compared with the corresponding inductive reactances. Thus, at low frequencies r' , which is R_p and R_o in parallel, is compared with the primary inductive reactance to determine relative gain. At high frequencies r'' , which is R_p and R_o in series, is compared with the leakage inductive reactance.

Equivalent Circuit Components

Circuit component values corresponding to those in Fig. 1 can be measured easily if these data are not available from the manufacturer. The required parameters are primary and secondary winding resistance, primary incremental inductance, leakage inductance, and the turns ratio. Load resistance is generally known and plate resistance is dependent upon tube operation. With this information on hand the equations in Fig. 1 can be utilized.

Winding resistance is generally measured with a resistance bridge. Although the a.c. resistance is desired, the d.c. resistance can be substituted in the audio-frequency range. When multiple windings are involved care must be taken to group properly those windings which constitute the complete primary or secondary.

It is important that the primary inductance be measured at a suitable frequency with adequate applied voltage. By this method the measured inductance is more representative of circuit conditions in the lower cut-off region. The usual values are 10 volts applied at 60 cps. This is minimum voltage which will produce a core flux density representative of normal operation for most transformers. The Hay inductance bridge may be used and the transformer secondary should be open-circuited.

If the circuit being designed is single-ended, the d.c. magnetization current must also flow through the primary winding (assuming series feed) when incremental inductance is measured. The amount of current should be the anticipated plate current plus that current

drawn through the primary winding by any other element such as the screen grid of a triode-connected pentode.

Leakage inductance is determined by the measurement of primary inductance when the secondary is short-circuited. An inductance bridge may be used. This measurement can be made at any convenient frequency and without passing direct current through the winding.

Finally, the turns ratio is measured by applying an a.c. voltage from a signal generator to the primary and measuring the resulting secondary voltage with a vacuum-tube voltmeter. The signal generator should be adjusted to a mid-band frequency in order to avoid high- or low-frequency attenuation.

Graphical Calculations

The 1- and 3-db attenuation frequencies can be determined rapidly for a given circuit by reference to the nomogram of Fig. 2. Low-frequency cutoff can be read on the left portion and high-frequency cutoff on the right portion of the chart. Thus, to determine the low-frequency cutoff, select the value of effective resistance on the r' scale and the value of primary inductance on the L_p scale. Join these points with a straight line and find the 1- and 3-db attenuation frequencies at the intersection of this line with the f scale.

To determine the upper limits of the pass band, enter with the effective resistance r'' . Join this point and the leakage inductance value on the L_s scale with a straight line. Once more the attenuation frequencies are found at the intersection of this line with the corresponding f scale.

Both of the above procedures are reversible. In this way a specified frequency can be selected, a straight-edge can be pivoted about this point, and combinations of inductance and resistance observed which will yield the desired frequency.

In the case of push-pull class A and class AB amplifiers, the same procedure can be used provided that the plate resistance is taken as twice the value for a single tube.

When applying this method to pentodes and beam power tubes the calculated upper cutoff may be high due to the large source resistance. In these cases the measured attenuation may be controlled by circuit capacitance rather than source and load resistances as shown in Fig. 1. Another precaution

* 2924 Selby Ave., Los Angeles 64, Calif.
¹ F. E. Terman, *Radio Engineers Handbook*, New York: McGraw-Hill Book Co., 1943; pp. 385-388.

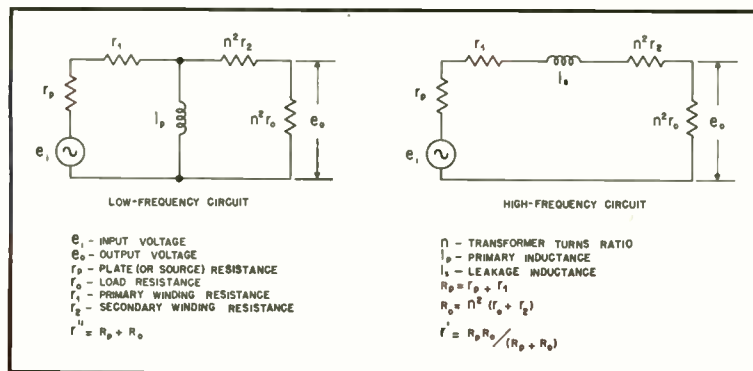


Fig. 1. Equivalent circuits of an audio transformer for low and high frequencies.

which should be kept in mind is that the application of negative feedback will increase the pass band and decrease the amplification of all stages within the feed-back loop.

Example

Consider the Triad HSM-89 transformer coupling push-pull KT-66's as Class A triodes to a 16-ohm voice coil. For this application the total plate resistance is 10,000 ohms (twice the single

tube value). Primary resistance is 265 ohms and secondary resistance is 0.489 ohms. Primary inductance is approximately 233 henries and leakage inductance is 35.7 millihenries. The turns ratio is 23 and n^2 is 529.

The load resistance referred to the primary is $529(16 + 0.489)$ or 8720 ohms. The effective resistance r' is $8720 \times 10,265 / (8720 + 10,265)$ or 4720 ohms, and r'' is $8720 + 10,265$ or 18,985 (use 19,000) ohms.

Construct a straight line from 4720 on the r' scale to 0.0357 on the L_s scale. Read 3.2 and 6.3 on the f scale. Thus, the lower 3-db frequency is 3.2 cps and the 1-db frequency is 6.3 cps.

Next, draw a straight line from 19,000 on the r'' scale to 0.0357 on the L_s scale. Read 43,000 and 85,000 on the f scale. Thus, the upper 1-db frequency is 43,000 cps and the 3-db frequency is 85,000 cps.

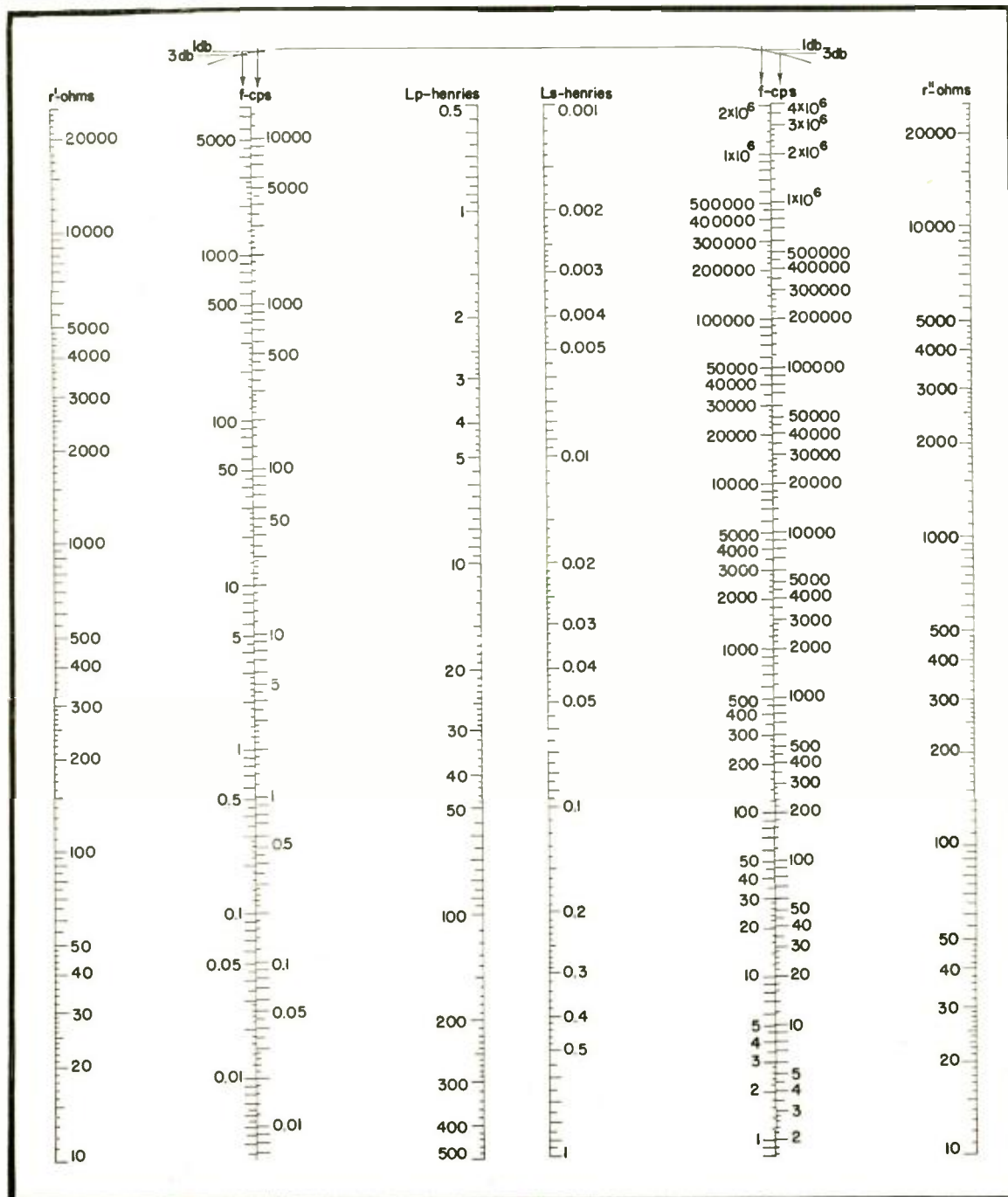


Fig. 2. Nomogram for determining the 1- and 3-db attenuation frequencies of an audio transformer.

Top Tape Recording Performance

HAROLD REED*

A discussion of some of the non-electronic factors affecting quality recording and reproduction of sound.

IN ADDITION TO maintaining the electronic section of a tape recorder in such condition that it will give the most efficient performance of which it is capable, it is of the utmost importance—in the interest of faithful recording and reproduction of sound—that the mechanical system be kept in peak operating status. This entails checking and testing of the various component parts of the mechanical layout, and especially—if the equipment is subjected to long hours of use, such as occurs in radio broadcasting and recording studios—this inspection and investigation into the competency of the system to approach recognized standards must be frequent.

One of the most important considerations is the alignment of the recording and playback heads. When only one recorder is being used and this machine is employed both to record and to reproduce the program material, and provided the recorder utilizes one head for both recording and reproduction, then some misalignment of the head does not necessarily result in sub-standard performance. In this circumstance the tape is drawn over the same head during both the recording and playback operations and, as the misalignment factor is identical for each operation, quality reproduction response may be obtained. This harmonious state of affairs is not in evidence when several recorders are in service and reproduction may be assigned to any one of the machines, nor when the mechanism employs separate record/playback

heads, unless all heads are in proper alignment. Further, inferior results may be obtained when playing tapes received from outside sources.

Incorrect head alignment manifests itself in poor quality in the form of muddy, distorted response, lacking in brilliance due to deficiency in reproduction of the higher audio frequencies present in the original program material.

In the moderate price range, Magne-cord recording equipment has proven to be quite popular and considerable thought and attention has been given to maintaining its mechanism in a high state of efficiency. The procedures outlined in this discussion, although based on tests with this particular mechanism, may generally be applied to other recorders.

* Chief Engineer WOL, 1000 Connecticut Ave., Washington 6, D. C.

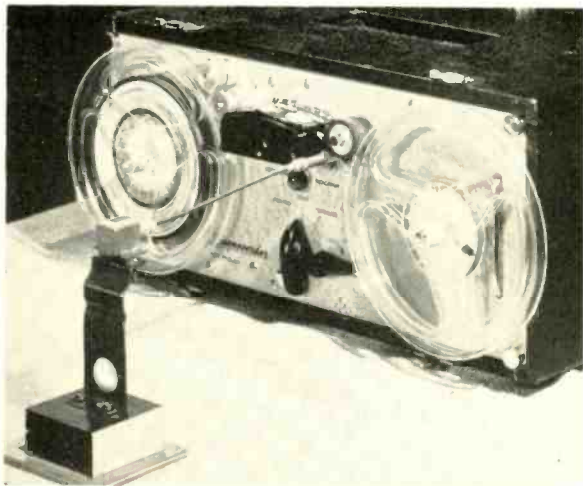


Fig. 2. Stand-mounted Vee-der counter is coupled to the capstan by means of a flexible shaft and the fitting described.

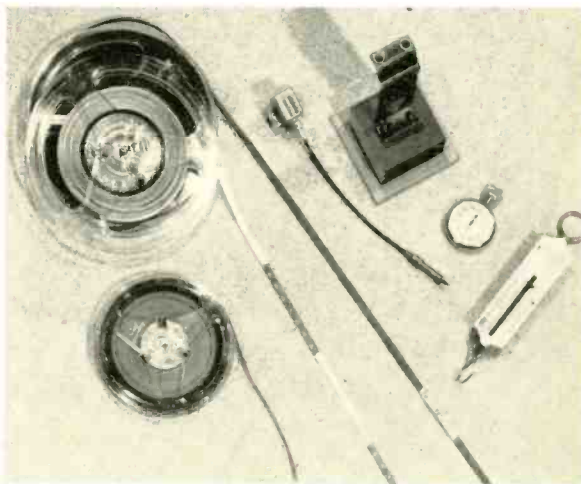


Fig. 1. A collection of several useful items needed in the maintenance of a tape recorder.

"Standard" Tape

To afford interchangeability of tapes between recorders the head gaps must necessarily be in alignment with each other. One suggested procedure, for a recorder with a single record/playback head, is to feed the signal output from an audio oscillator at about 7500 cps for 7½-in. machines, or 15,000 cps for 15-in. machines, into one of the amplifiers, recording this signal for use as a "standard" for all others. This so-called standard tape is then reproduced on each of the other machines and the head adjusted to obtain maximum output from each recorder by observing the volume indicator or other signal level indicating device. The head adjustment consists simply in turning an adjustment screw in or out with a screwdriver to change the physical position of the head gap with respect to the tape, until maximum response is acquired. This procedure will ensure good high-frequency response for all the machines aligned in this manner, even if the unit used as a standard is in misalignment. However, as indicated previously, tapes received from outside sources that may have been recorded on a mechanism in perfect alignment may not faithfully reproduce the program material when played on recorders aligned as indicated above.

A more satisfactory way to accomplish head alignment is to employ a standard alignment tape such as is used in the factories of recorder manufacturers, and obtainable from most large jobbers. It is simply then a matter of adjusting each machine for maximum output as the standard tape moves over the head.

So far we have considered the recorder containing a single head for recording and reproducing, and of course, an erase head. In the case of machines containing a three-head assembly—that is separate record, reproduce, and erase heads—the same standard alignment tape is used but the procedure is not quite as simple as with the single head unit.

The playback head is aligned first. These assemblies contain locking screws at the bottom of both heads, which must first be loosened. Then with the recorder set on playback, and the alignment tape running over the assembly, back off the alignment screw—accessible through a small hole in the front of the case of the head—to establish definitely that the head is out of alignment, as indicated by the volume indicator. The locking screw under the playback head is then tightened, and the alignment screw turned in a clockwise direction to bring the head into alignment, as noted by maximum indication on the meter. If the alignment screw is turned too far—that is, beyond the peak response indication on the volume indicator—it will be necessary to start again at the beginning of the process.

The record head must now be brought into alignment. The standard tape is removed from the recorder and a blank tape installed on the machine. With the standard alignment tape on another recorder, its output is fed into the machine being adjusted, which is now set in RECORD position. Adjustment procedure as described for the playback head is followed, again obtaining maximum indication on the volume indicator connected so as to measure the output of the machine being adjusted. This completes adjustment of the three-head assembly. If the second recorder is not available, an audio oscillator can be used as the source of the high-frequency signal for this alignment procedure. On heads without locking screws it is advisable, after alignment, to place a small dab of speaker cement on the adjusting screw head where it rests against the head case, to prevent changes due to vibration of the machine. This cement is easily broken loose when further alignments are to be made.

Worn heads will result in poor frequency response, this condition manifesting itself in a falling off of the higher audio frequencies. The heads can be expected to give satisfactory service for about 1000 hours or more, depending upon such factors as the care with which the mechanism is handled and the operating speed employed. Tape should never be in contact with the heads during the high speed rewinding process. Dirty heads also contribute to a loss of the higher audio frequencies. Some of the minute particles of the tape coating wear off and cling to the head laminations. Thus the heads should be cleaned frequently with a lintless cloth and absolutely clean carbon tetrachloride.

Erase heads normally have con-

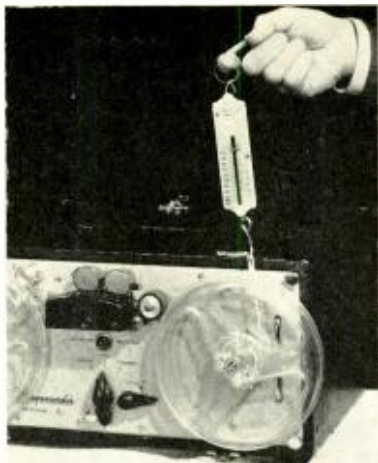


Fig. 3. Method of using string and spring balance to measure the pull of the mechanism in ounces, for later transformation to torque in inch-ounces.

siderably greater life than the record/playback heads and usually require no physical adjustment. If the bias oscillator is supplying the proper erase voltage and the tape is not being erased completely, the erase head should be replaced. Heads may be obtained on a revolving stock basis, credit being given for return of the worn head to the factory.

Speed Accuracy

To obtain top performance, the recorder mechanism must be maintained at the correct rotational speed. Without close speed control, not only will timing errors in reproduction occur, but pitch variations may become noticeable. Several methods were tried in an attempt to determine easily the speed of any recorder, to correct speed discrepancies, and to keep timing errors within a reasonable tolerance.

It was estimated that at the popular $7\frac{1}{2}$ in./sec. tape speed, 562.5 feet of tape should pass over the heads in 15 minutes, 1125 feet passing over in 30 minutes. For this test a new recording tape was marked off with a steel tape measure, and white splicing-tape markers

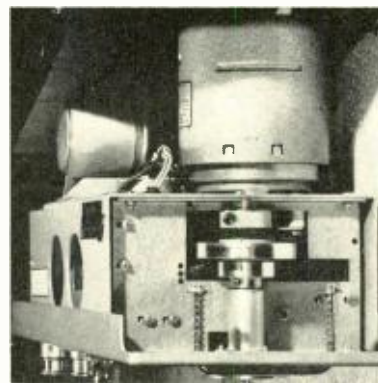


Fig. 4. Take-up assembly of Magnecorder, showing the clutch with the knurled split adjustment nut at the end of the shaft.

were attached at 187.5, 375, 562.5, and 1125 feet, corresponding respectively to 5, 10, 15, and 30 minutes. In normal operation of the mechanism the marker of any particular footage should be drawn over the head at the corresponding time required to pass this amount of tape.

Another method is to employ a leader and timing tape which is available in 150-ft. reels in various forms to indicate known lengths, with marking means at fixed intervals. Several of these timing tapes can be spliced together and markers attached at any time intervals desired. Figure 1 shows a typical timing tape, a marker on a piece of standard tape, and several other aids to recorder maintenance.

An interesting technique tried in this speed control problem consisted of counting the revolutions per minute of the recorder capstan. In testing new Magnecorders it was learned that the rotational speed of the capstan was about 6.35 revolutions per second, 381 per minute, 5715 per 15 minutes and, 11430 per 30 minutes. A tachometer was used to clock the capstan speed and although a practical method, there was concern about the accuracy because of the possibility of reducing the speed due to the pressure required to engage the tachometer to the capstan.

What was considered a more satisfactory method was in the use of a Veeder counter. The torque necessary to turn the counter is negligible so that no appreciable error occurs when it is connected to the capstan. A short length of $\frac{1}{4}$ -in. copper tubing was used to couple the flexible shaft from the counter to the capstan. With a hack saw, a slot was cut across the tubing diameter so that it fitted in the coupling at the end of the counter flexible drive. A machine screw with the correct thread to fit the capstan shaft, was soldered into the opposite end of the copper tubing. This affords direct drive between the capstan and Veeder counter. With the recorder and counter running, the rotational speed in revolutions per minute is clocked with a stop watch. The counter was fitted with two small banana plugs, which in turn fit into banana jacks mounted on a metal support. This assembly is attached to a wooden base, which rests on the bench or table and eliminates the need for holding the counter during the checking. The arrangement is shown in Fig. 2.

Tape Tension

A number of factors contribute to timing errors and speed variations. Clutches at the rear of both the supply and take-up reel spindles are employed to produce the proper tape tension to prevent either throwing or stalling of the tape. Clutch friction on the supply reel should be just great enough to prevent throwing the tape when the mechanism is stopped. Excessive resistance at

(Continued on page 59)



Left: Charles Edison, Chairman of the Board of Thomas A. Edison, Incorporated, receives dictating machine award from *Æ* editor C. G. McProud. Center: Dr. Irving I. Schachtel, president of Sonotone Corporation, accepts hearing aid award. Right: Dave Oppenheim, director of Masterworks Division, Columbia Records, Inc., being tendered classical award certificate won by Columbia's president, James B. Conkling.

Audio Engineering Awards

Reports of the various committees of judges show the reasons for the selection of the award winners announced last month.

COINCIDENT with the delayed distribution of the May issue of *Æ*, a press party was held at the "21" in New York to announce the award recipients, and to make formal presentation of the certificates, one of which is shown below. Over one hundred representatives of the press, company officials, and recording artists were on hand for the occasion. After the awards were presented, the reports of the various committees of judges were made public. Since *Æ* readers have expressed interest in the complete reports, they are being offered herewith. To a large extent, the reports indicate the methods by which the decisions were made.

In the dictating instrument and hear-

ing aid categories, the committees studied the individual units thoroughly within the criteria by which they were being judged, and in both categories the decisions were unanimous. In the recording categories, there was naturally some difference of opinion. The records were played on a typical high-quality installation set up by Irving Greene of Asco Sound Corporation in a suite in the Commodore Hotel. All equipment used was of well known make, and was considered by the committee as being satisfactory. Judging was on the basis of musical excellence and of technical excellence, with separate scoring for each. At the conclusion of the listening, the scores were averaged to obtain the

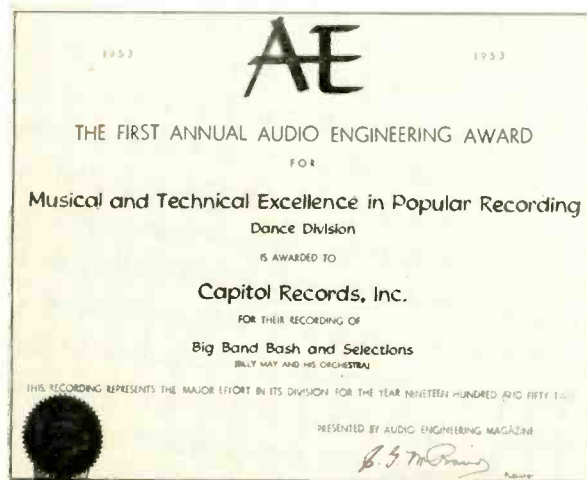
final figures. Since some of the committee members were not musicians, their scoring was restricted solely to technical quality. The complete reports of the various committees follow:

Dictating Instruments

One of the major considerations in establishing the Audio Engineering Awards was the need for a study of consumer applications of audio engineering theory and techniques. Dictating instruments represent such an application to consumer needs and were selected as one of the divisions for the 1953 awards.

However, to make such a study and award realistic, functional standards had to be created. In other words, it was the responsibility of the Committee to determine clearly what the primary functions of dictating instruments are in terms of the consumer, and the degree to which the various instruments satisfy these requirements. With these standards in mind, the Committee could then approach the technical analysis of the instruments from a realistic point of view. These functional requirements included simplicity and ease of operation, simplicity and ease of transcription, durability, simplicity of maintenance, and the degree to which the given instrument supplied the fullest range of dictating needs.

Most important of all was the necessity of defining the audio requirements of dictating instruments. It goes without saying that dictating instrument recording is not to be equated with musical or other forms of recording where wide-range reproduction is requisite. Nor is it intended to reproduce the human voice merely for the sake of such reproduction. In a sense, dictating instrument recording has one purpose: to make it possible for the transcriber to hear with a high degree of intelligibility the syllables which are to be transcribed. It is especially important that the person transcribing the recorded material be able to understand every syllable; it is not enough that she be able to follow the meaning by the grasp of most of the words, as is adequate in ordinary conversa-



Reproduction of one of the award certificates received by Capitol Records, Inc.



Left to right: Henry L. Gage, vice-president of Westminster Recording Co. Inc.; George R. Marek, Director of Artists and Repertoire, RCA-Victor; Peter Bartok, president of Bartok Records, Inc.; William H. Fowler, vice president of Capitol Records, Inc.

tion. It is imperative, therefore, that the instrument reproduce all the sounds dictated for a rapid and efficient translation of the dictated material to the typewritten page. Furthermore, the dictating instrument recording should present this material with a minimum of fatigue factors, including surface and other background noises.

With reference to the instrument itself, it should be considered as a time-saving and work-saving tool. Where it creates obstacles in the form of difficult, complex operation, complicated indexing, etc., it fails to supply the needed advantages for which it was originally purchased.

It is the unanimous decision of this Committee that the Award be given to Thomas A. Edison, Incorporated for the V. P. Edison Voicewriter. Judged by all the aforementioned criteria, this instrument is preeminently successful. Quality of reproduction is excellent. Furthermore, the instrument has been ingeniously designed to provide for extreme simplicity of operation as either a dictating or transcribing instrument. Size and shape have been so controlled that the instrument is not merely portable, but "carryable" as well, making it possible for it to be easily and conveniently used outside the office. Since it is a multitype instrument, it is particularly suitable for the small office which needs only one instrument and thus can be equipped for a lower cost.

Hearing Aids

The committee studying the design and construction of hearing aids did not attempt to evaluate the performance of the instruments in the alleviation of the hearing loss—that is the function of the otologist. Since there are many types of hearing loss, with many of these requiring specialized equipment to provide satisfactory hearing, it was felt that it would be unwise to perform the function of a research laboratory in evaluating the various instruments. Furthermore, the scope of the award is not intended to make any such comparison. It should be pointed out specifically that the opinion of this committee should not be considered an endorsement of the instrument as a hearing aid, but that it should be considered solely as an evaluation of the circuit design and its embodiment in a manufactured product.

In studying these instruments, the committee kept in mind the various criteria by which they should be judged. If the award were to be given for lowest cost of operation alone, obviously one of the all-transistor hearing aids would be chosen. If size were to be the governing factor, then the internal design might have to be skimped to keep the over-all dimensions of the instrument within the limits established. The general points studied included both size and cost of operation, but these were not made

of maximum importance.

While the all-transistor hearing aid undoubtedly offers somewhat lower cost of operation, it is felt that the present status of development does not warrant the use of transistors in the low-level first stages of a hearing aid because of increased noise. It is considered probable that this defect will be remedied at some time in the near future.

Considering the mechanical and electrical features of all of the hearing aids studied, it is the unanimous opinion of the judges that the major effort in hearing aid design and production has been achieved by Sonotone Corporation in its Model 1010. The judicious use of a transistor in the output stage, where its high electrical efficiency is most advantageous, is commended. Cost of operation is reduced considerably below that of the all-vacuum-tube hearing aid without sacrificing quiet operation. Also noted were desirable mechanical features such as separation of volume control from the on-off switch, and the sturdy plug connections between the instrument and the earphone, the accessory microphones, and the telephone pickup device. With respect to weight and compactness, the instrument compares favorably with all others studied.

Classical Records

The Committee was particularly careful to design test conditions which would eliminate any factors which might interfere with an objective appraisal of the musical and technical quality of the recordings. Fine equipment was used and the members of the Committee were all given an opportunity to adjust themselves to the characteristics of the equipment.

Twenty manufacturers were invited to submit what they considered their major recording in five categories for the year 1952. These categories were: symphonic, chamber, solo instrumental, vocal, and operatic. Sixteen companies submitted recordings. The Committee determined to ask the manufacturers to choose their major recordings because such a device would supply a means of determining what were the manufacturers' own attitudes toward classical recording in terms of performance and technique. On this score, the Committee found that many of the records submitted were poor both musically and technically. These below-standard recording efforts were marked by distortion, surface noise, poor balance, simple inadequacy on the part of the performer or performance, and in some cases, sloppiness. Furthermore, the Committee decided that on the basis of this experience, the next awards would consider choice of repertoire a significant factor in scoring.

Without exception, however, the winning recordings were of an unusually distinguished nature, and in each category, one or two additional recordings were also of high caliber. It would

be impossible to attribute a monopoly of quality to either the major companies or the smaller and more recently organized manufacturers. Poor quality was predominantly found in the recordings submitted by the small manufacturers but, at the same time, many of them produced recordings of a superb nature. In the case of the larger manufacturers, generally speaking, the quality of the recording was considerably better than that obtainable only a few years ago. Their major deficiencies apply to the musical aspects of the recording.

The Committee was impressed by the general advance in 33-1/3 r.p.m. microgroove recording and dismayed by the prevalence of such obvious technical blunders as tape noise and poor surfaces. These were limited, however, to a minority.

Popular Records

Of an extremely large quantity of records submitted to this Committee, it was necessary to disqualify over 90 per cent in each of the popular categories. These categories were: dance, jazz, vocal, musical comedy, and novelty, with a separate category devoted to folk music in general. The Committee was well aware of the practical problems faced by the popular recording manufacturer. His major markets are the juke box and the home consumer with an inexpensive and low-grade record player. Therefore, he feels the need to manufacture records for consumers who will ordinarily turn the bass control, if they have one, all the way up and the treble all the way down. His products, therefore, are not designed for superior instruments and this is the justification for the low-quality recordings that ensue. High distortion is only one of many unsatisfactory conditions found throughout. We should cite especially some of the radical peaking techniques employed.

Of the remaining records that were submitted to the final Committee, quality was somewhat better, but in no sense up to acceptable recording standards if we are to eliminate the practical considerations faced by the popular recording manufacturer.

Musically, most of the material was sub-standard, as is common knowledge. It is certainly not news to recognize that this is not a period of great popular music or of great popular performance. In the jazz category, it was the older distinguished veterans who aroused attention. It would be unfair to place all the blame on the shoulders of the popular record manufacturer who is forced to submit to the many market conditions which affect his final product. It must be pointed out, however, that it was the opinion of the Committee that the winning recordings unquestionably represent considerable superiority over every other single recording submitted.

Handbook of Sound Reproduction

EDGAR M. VILLCHUR*

Chapter 11. Part II. Loudspeakers (Cont'd).

Continuing the discussion of loudspeaker performance in relation to the enclosure in which the speaker unit is mounted.

The "R-J" Enclosure

The "R-J" enclosure¹ (see Fig. 11—10), a fairly recent commercial device, makes use of the same type of Helmholtz acoustical resonance as the bass-reflex cabinet. The small volume in back of the cone makes the air cavity stiffness very great, but this stiffness is counterbalanced through the duct arrangement which injects a large amount of inertia and viscosity into the system. The acoustical resonator is not tuned to the exact resonant frequency of the speaker mechanism. However, the acoustical resonant peak is reduced by the high viscosity in the duct spaces. This viscosity reduces the mechanical as well as the acoustical resonant peak. Unlike the bass-reflex cabinet, the R-J enclosure imposes an added inertia-resistance load to the front of the cone as well as to the back.

It will be seen, in Fig. 11—10, that the electrical analogy of the R-J enclosure

is the same as that of the bass-reflex cabinet. The differences lie in the high values of M and R, and the low value of C.

The R-J enclosure was designed with the particular purpose of reducing the size of an adequate speaker enclosure. Reduction of size also entails simplification of other problems, such as those concerning vibration of the cabinet walls.

The Acoustical Labyrinth

In the original design of the acoustical labyrinth² (Fig. 11—11) the back of the speaker faces into a column which is half a wave length at some low frequency at which the speaker is deficient. The required dimensions of such a column are so large that it must be folded back on itself for practical application. Sound emitted from the end of the column into the room at the half-wave-

length frequency will be in phase with sound from the front of the cone, and total output will be increased in this frequency region. The walls of the column are lined with sound absorbent material so that higher frequencies, above 150 cps or so, are not transmitted.

The anti-resonant characteristics of this device may also be used, as in the tuned port enclosure, to inhibit voice-coil travel at speaker resonance. In this case, however, the mode of air resonance involved is that of the air column. The length of folded conduit must be an odd multiple of a quarter wave length of the speaker resonant frequency, that is, $\frac{1}{4}$, $\frac{3}{4}$, etc. of the wave length. An odd-quarter-wave column returns sound to the speaker out of phase with motion of the back of the cone. Reflection from the end of an open pipe suffers a 180-deg. phase reversal, and the reflected wave, having gone through a reversal of both phase and direction, returns to apply a pressure to the back of the cone which opposes motion induced by the input signal.

If the $\frac{1}{4}$ wave-length anti-resonant characteristics of a labyrinth enclosure

* Contributing Editor, AUDIO ENGINEERING.

¹ William Joseph and Frank Robbins, "Practical aspects of the R-J speaker enclosure," *AUDIO ENGINEERING*, V. 37, No. 1, p. 19, Jan. 1953.

² Benjamin Olney, "A method of eliminating cavity resonance, extending low frequency response and increasing acoustic damping in cabinet type loudspeakers," *J. Acous. Soc. Am.*, V. 8, p. 104, Oct., 1936.

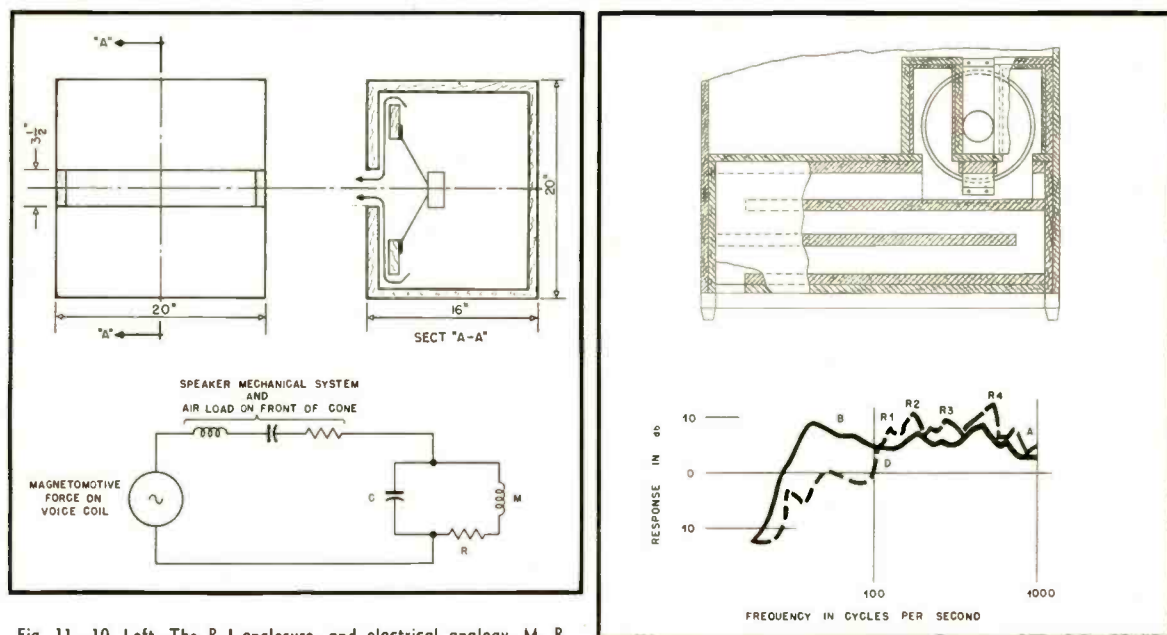


Fig. 11—10. Left. The R-J enclosure, and electrical analogy. M, R, and C represent the acoustical mass of the ducts, the viscosity of the ducts, and the compliance of the enclosure, respectively. Fig. 11—11, Right. The acoustical labyrinth (drawing from the original U. S. patent, No. 2,031,500).

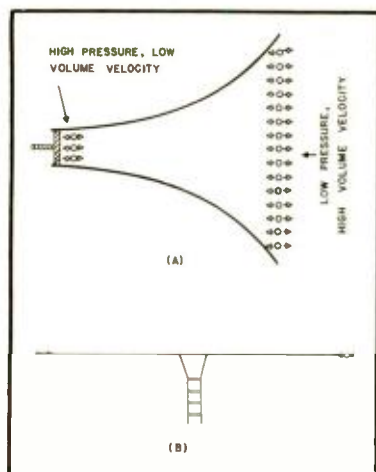


Fig. 11-12. (A) the acoustical horn as an impedance matching device (B) the same principle used in matching an antenna to a transmission line. (Delta match)

are to be used, the frequency corresponding to the conduit half wave length falls an octave above speaker resonance, where no speaker deficiency is to be expected. Uncalled for acoustical emphasis at this frequency must therefore be guarded against.

General Considerations in Design and Construction of Cabinet Enclosures

The stiffness contributed by the air space behind the speaker is not the only problem which is encountered in cabinet design. The design precautions appearing below apply to all of the enclosed cabinet types that have so far been discussed.

Independent standing-wave resonances, created by internal reflections between parallel surfaces, may be set up within the enclosure. Such resonances are particularly annoying because they occur at higher frequencies. They may be eliminated or reduced by lining the inside of the cabinet with sound absorbent material (preferably with a small air space between the material and the cabinet wall) to damp out oscillatory reflections. The same effect is produced by filling the entire volume with some soft cotton-like substance. Special lin-

ing material such as Kimsul or Fiberglas is made for this purpose, although ordinary rug cushioning, tacked loosely to all inside surfaces, is usually adequate. Certain cabinets have been designed with curved internal surfaces in order to make the conditions for air-column resonance unfavorable.

The walls of the cabinet are another source of unwanted resonance. Unlike a stringed instrument's wooden belly, which is vital to the tone of the sound, a good cabinet does not vibrate in sympathy with the music. Concrete or brick enclosures are ideal, but involve obvious inconveniences. Wooden cabinets must be sturdily built, with joints glued and reinforced. No material thinner than $\frac{3}{4}$ -in. stock should be used anywhere, including the back, and the builder should attach crossbars firmly to the larger panels in order to increase rigidity. Since totally enclosed cabinets have greater pressure exerted against their walls than cabinets which are partly open, they must be particularly well braced. The writer once saw a case where a pronounced acoustical peak, at about 175 cps, cleared up completely when the $\frac{3}{4}$ in. plywood cabinet back was replaced by one of sturdier construction.

The grille cloth in front of the speaker may also affect performance. This cloth must be of very loosely-woven material, such as burlap. A simple check of the suitability of a cloth may be made by stretching it across one's lips and blowing through it; there should be no appreciable resistance to the flow of air. A metal grille for decoration and protection does no harm if it cannot rattle and if it does not obstruct any appreciable area of the speaker cone.

Additional elements of cabinet design which have an effect on speaker performance have been pointed out.³ One of these is the short air column formed by the thickness of the baffle into which the cone faces. It has been demonstrated that the evenness of high-fre-

³ Harry F. Olson, "Cabinets for high-quality direct-radiator loudspeakers," *Radio and Television News*, V. 45, p. 53, May, 1951.

TABLE 2

Absorption coefficient vs. frequency for various materials. (After Olson)

Frequency, cps.	128	512	1024	4096
1 in. Fiberglas tile	.22	.97	.90	.52
Cotton Draperies (10 oz. per sq. yd.) hung straight, in contact with wall	.04	.11	.18	.44
Same as above, but velour, 18 oz. per sq. yd.	.05	.35	.45	.44
Velour, hung 4 in. from wall	.09	.45	.52	.44
0.4-in. carpet, on $\frac{1}{8}$ -in. felt, on concrete	.11	.37	.43	.27
0.8-in. wood sheathing, pine	.10	.10	.08	.11
Unpainted brick wall	.024	.031	.042	.07
Painted brick wall	.012	.017	.020	.025
Plaster on wood lath, rough finish	.039	.061	.089	.07
$\frac{3}{4}$ -in. Ozite	.09	.28	.51	.47

TABLE 1

Optimum reverberation time vs. frequency and room volume. (Values from Olson)

Room Volume, cu. ft.	1,000	2,500	5,000
Optimum reverberation time at 50 cps	0.8 sec.	0.9 sec.	1.0 sec.
Optimum reverberation time above 1,000 cps	0.7 sec.	0.79 sec.	0.85 sec.

quency response is improved if the speaker is mounted almost flush with the front surface of the baffle. The points of speaker support may be inset, by an amount consistent with mechanical strength.

Performance is also improved by designing the cabinet so that the front does not form a right angle with the sides.⁴ Diagonal or curved corners may be used instead, which mitigate irregularities in frequency response caused by diffractive effects around the cabinet edges. The diffracted waves have a phase relation to the directly radiated sound which varies with wave length, producing reinforcement at some frequencies and cancellation at others.

These last two design factors are usually considered to be less important than the ones preceding, and many cabinets do not take them into consideration.

Horns

One of the most ancient of all acoustical couplers is the horn, the principle of which is used in as simple a procedure as putting a cupped hand to the mouth. A horn is not a generator of sound, but an inert coupling device which enables a relatively small vibrating source to engage large volumes of air.

The air in a horn may be conceived of as a succession of cross-sectional layers. A vibrating body (such as a diaphragm) at the narrow end, or *throat*, is in immediate contact with the first of these layers. Air movement resulting from the vibrations is confined by the

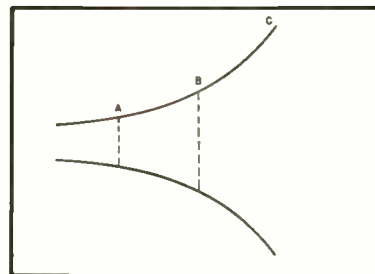


Fig. 11-13. Illustration of independence of cut-off frequency from horn length. Horns terminating at A or B will have the same cut-off frequency as will the complete unit, since the rate of flare is the same. Reflections from the smaller diameter mouths, however, will be much worse.

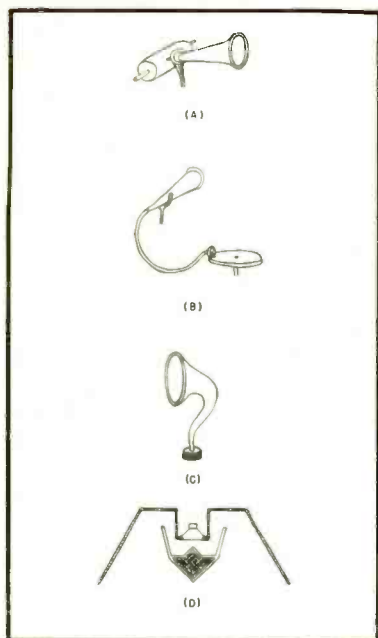


Fig. 11—14. Development of the horn in reproducer design (A) rigidly coupled to reproducer (Edison); (B) attached by flexible tubing (Berliner); (C) curved to conserve space, and with exponential flare; and (D) modern folded bass horn for use with direct-radiator driver

walls of the horn to each successive layer, and since there is only a small change in area from one layer to the next, very little energy is wasted in the transfer. The result is that the vibrating source is strongly coupled to, and moves, all of the air in the horn, and the effective radiating area of the source, as seen from the point of view of the room receiving the sound, is increased towards the area of the large end, or mouth of the horn. The increased air-load impedance raises the mechanico-acoustical efficiency of the source through the resistive component, and lowers the resonant frequency of the source through the acoustical mass component. The acoustical mass reflected into the mechanical system of the source may be so great as to overshadow the mechanical mass at lower frequencies.

The horn as an impedance-matching device is illustrated at (A) in Fig. 11—12. The condition of high pressure and low volume velocity of the air in immediate contact with the vibrating source is gradually transformed to the low pressure and high volume velocity at the horn's mouth. The impedance discontinuity between each layer of air in the horn is very small, so that reflection does not occur.

In Fig. 11—12, (B) is an electrical "horn" whose operation is analogous to the acoustical device. This horn is an actual impedance matching device used in connection with matching an antenna to its transmission line; the increased spacing between conductors changes the capacitance, and hence the total line impedance, and at such a gradual rate that

reflection and energy losses are avoided.

The three most significant characteristics of horn design that determine its performance are: (1) type of flare (i.e. conical, exponential, etc.) (2) rate of flare and (3) diameter of mouth.

The conical horn was used in early phonographs, and is still to be seen in the megaphones employed by cheerleaders. Modern reproducing horns, however, are almost all of an exponential or related type, that is, the cross-sectional area increases as a function of an exponential variable.

The exponential horn flare may be expressed by the equation:

$$S = S_0 e^{KX}$$

where S = cross-sectional area at point X
 S_0 = cross-sectional area at throat
 e = 2.718+
 K = a constant
 X = distance along horn axis. (Note that at the throat, where $X = 0$, $S_0 = S$.)

This type of horn is considered as increasing the effective area of the vibrating diaphragm at its throat approximately to that of its mouth.

A horn has a low-frequency cut-off which is determined by its rate of flare, below which frequency the diaphragm is unloaded and the acoustical radiation is practically zero. The more gradual this rate the lower the cut-off frequency, so that bass horns require a very slow flare. A horn with a given flare will exhibit the same cut-off point regardless of its length, as shown in Fig. 11—13, although the decreased mouth diameters associated with the shorter lengths will affect performance in other ways.

$$F_{\text{cut-off}} = \frac{KC}{2\pi}$$

C = constant of flare equation
where K (above) = velocity of sound

The size of the horn mouth determines the degree of impedance discontinuity

between the mouth and the area into which the horn radiates. The smaller the mouth diameter in relation to the wave length of the sound the greater will be the reflection of sound from the mouth back to the throat, and the greater the irregularities, especially near the cut-off frequency. For relatively smooth reproduction the mouth diameter is generally made equal to at least one-third the wave length of the lowest frequency to be reproduced. A low-frequency horn, combining a slow flare with a large mouth diameter, must thus be very long.

The size of the horn throat is also significant, aside from questions of flare. The smaller the throat area the greater will be the acoustical pressures built up. Air is itself non-linear—the change of volume velocity is not exactly proportional to pressure changes—but this effect is negligible except when very large pressures are built up. The absolute diameter of the throat area, therefore, is a limiting factor in the power handling capability of a horn when a given percentage of distortion is postulated. The larger the throat area the greater the power handling capability.

Because of the large increase of air-load impedance that properly designed horns make possible they are the most efficient of acoustical couplers (efficiencies of from 25 to 50 per cent for horn systems are usual); they lower the resonant frequency of the mechanical system of the driver by the greatest amount; and they enable a given speaker to perform with least distortion and frequency irregularities. The diaphragm excursion is severely reduced for the same acoustical power, and mechanical resonances are highly damped by the air resistance engaged by the horn mouth and reflected back to the throat. The disadvantages of horns lie in their size and difficulty of construction. The

(Continued on page 35)

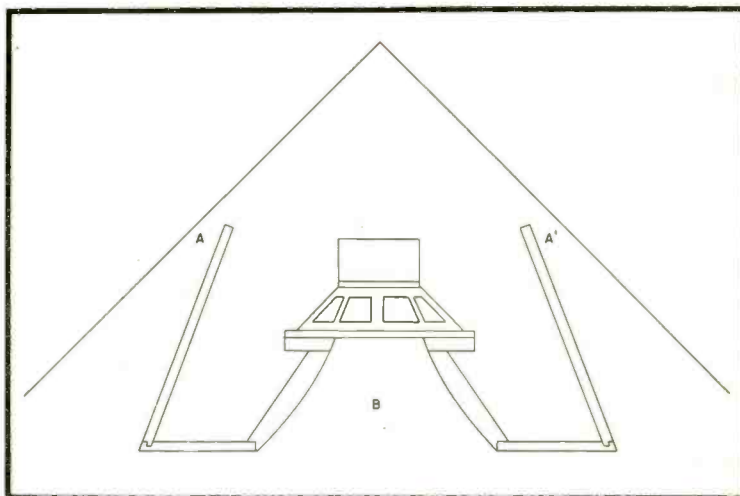
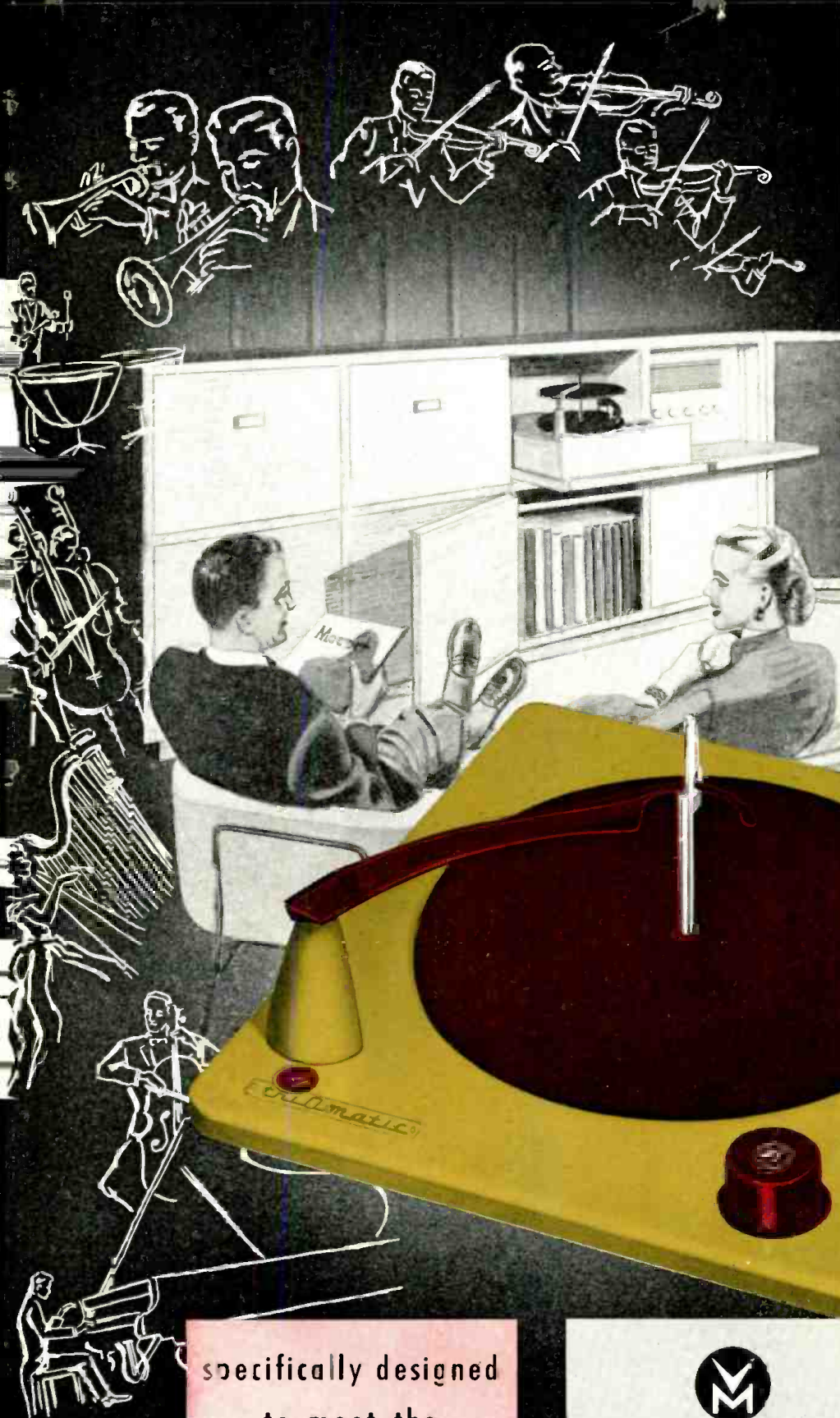


Fig. 11—15. McProud corner cabinet, combining reflex ports and horn loading.



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4. Die Cast Tone Arm of aluminum, is rigid and resonance-free! Is balanced for easy, exact adjustment to needle pressures specified by needle or cartridge manufacturers.

5. A Minimum of Lateral Pressure is required to track and trip the friction-free V-M 935HF changer. Cartridges requiring down to 5 grams needle pressure can be used with excellent results.

6. Muting Switch for absolute quiet during change cycle.

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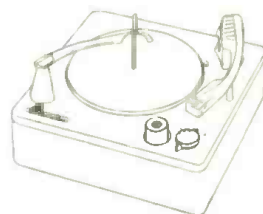
8. Exclusive Four-Pole, Four-Coil Motor with surplus power for silent, constant-speed service, eliminates the source of electronic hum and rumble.

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(from page 32)

sharpness of the horn radiation pattern, as in the case of direct-radiator loudspeakers, is inversely proportional to the frequency being reproduced and to the effective radiating area at the mouth.

Horn-type loudspeakers are made as a unit in certain models, notably tweeters (where the high frequencies involved make possible small mouth diameters and relatively fast rates of flare) and public-address speakers. Where the horn is thin-walled for economy, a damping ring is usually applied to the rim of its mouth for the purpose of dissipating wall vibrations and to prevent reflection in the material itself. This is comparable to the edge damping employed in some cone speakers.

Horns are also used as separate coupling devices, driven by speakers designed as direct radiators. For practical use at bass frequencies the horn must be folded by reason of the required length.⁵ Figure 11-14 illustrates the development of reproducer horn design over the past seventy-five years.

Variations in Basic Design

Many variations and combinations of the basic speaker mounting systems described in this chapter are possible. Horn-loading on the rear of the cone, for example, may be combined with baffled direct radiation from the front. Another design variation appears in the McI'roul corner cabinet,⁶ a reflex enclosure whose ports are horn-loaded by the cabinet and room walls (see Fig. 11-15). The ports of this enclosure are highly damped by the radiation resistance of the horns, and the resistive component introduced into the Helmholtz resonator is so great that critical tuning is no longer necessary.

Mounting Location and Room Acoustics

There is not too much that can be done about room acoustics, but the mounting location of the speaker can be chosen to counteract acoustical disadvantages:

1. The high-frequency speaker should command as much of the room as possible, so as not to have the treble confined to a relatively narrow beam. Treble dispersion may also be achieved by using indirect sound; one enclosure design⁷

makes use of a section of an ellipsoid of revolution to reflect and disperse sound in many directions.

2. If possible the bass speaker should face into a reduced solid angle in order to increase the efficiency of the acoustical "bite."

3. Efforts should be made to avoid the formation of standing waves between parallel reflecting surfaces.

Catercornered mounting is thus ideal on all of the three counts above. The room itself can also be treated acoustically, but aside from a few hard-bitten bachelor acousticians this is not a practical procedure, except to a very limited extent. The reflection characteristics of the room surfaces are very important, affecting reverberation time and the tendency to room resonances. The reverberation time, relative to room volume and frequency, that is considered optimum is listed in Table 1. Too low a reverberation time creates a "dead" tone. If taste runs to heavy rugs and wall drapes, overstuffed furniture, and an acoustically treated ceiling, this result may be expected. Such room characteristics have an additional significance beyond the direct effect on reverberation—the absorption coefficient of most materials varies with frequency (see Table 2), and the intensity levels to which the higher frequencies build up may be discriminated against more than they would be in the typical concert hall.

When the room is too reverberant, on the other hand, musical tones are smeared rather than blended, and the distinctness of orchestral voices is impaired. This effect is likely to be found in modern-style rooms with bare, polished surfaces, no upholstered furniture, and a severe regularity of shape which encourages standing waves. The use of rugs, drapes, and screens to make the reflecting surfaces more absorbent and to break them up, all serve to alleviate the situation. An open window, of course, may be considered as a perfectly absorbent body, since it returns practically no sound.

Reverberation time has been measured roughly by ear and stop-watch, but accurate measurement involves much more complicated equipment. Since the optimum time cannot be rigorously determined anyhow, the general subjective impression of musical quality may serve to give some indication of the reverberation characteristics of the living room.

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- Harry F. Olson, "Elements of Acoustical Engineering," D. Van Nostrand Co., New York, 1947, Chapters 6 and 7.

⁵ The "Klipschorn," which uses the room walls as part of the horn, is an example of this type—see Paul W. Klipsch, "A low-frequency horn of small dimensions," *J. Acoust. Soc. Am.*, V. 13, Oct., 1941.

⁶ C. G. McProud, "A new corner speaker design," *AUDIO ENGINEERING*, v. 33, Nos. 1 and 2, Jan.-Feb., 1949.

⁷ Philippe Forestier, "A step towards high-fidelity reproduction: the 'Focalizing Baffle'." (in French) *TSE et TI* No. 280, Feb., 1952.

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Patentable Features in Radio Inventions

ALBERT WOODRUFF GRAY*

Patentability of an invention is based upon a number of specified requirements—all of which must be fulfilled to warrant the granting of a patent. The author lists these requirements, and cites examples of familiar devices.

A FEW YEARS AGO the Federal Court in Michigan said in a decision holding two radio patents invalid, "Where, as here, it appears that a patent has merely accomplished an old result by a combination of means which, singly or in a similar combination, were disclosed by a prior art, and the patent has made no advance over the prior art beyond that which would be accomplished by a mechanical skill in the art, there is no patentable invention."

In this instance the inventor of a "peak detector" and an "amplifier volume control" suffered the same disappointment he did in another adverse decision relating to a radio patent where Judge Learned Hand, of the Federal Appellate Court said of radio patents,

"Especially in the radio art is it dangerous to be impressed by new details: the subject is all very unfamiliar to us; we must proceed quite in the dark guided only by the interested advice of those whose conclusions we are personally unable to check as we sometimes can in the mechanical arts. The industry has been the object of an amazingly assiduous ingenuity and we are to suppose that many permutations will appear spontaneously from the constant efforts of numerous competitive experimenters. True, this may be used as special evidence of invention when the need is old and the success striking, but it counts strongly against the novelty merely as such."

"We put this patent down as one of those step by step advances not beyond the compass of capable investigators who run down every lead and cull out those which appear advantageous. It might be desirable to promote such activities by limited monopolies, but that is not the law. Patents do not go to patient and exhaustive experiment, they are the reward of exceptional talent."

The law by which the Federal Court measured these discoveries for the qualifications required for patent protection, provides, "Any person who has invented or discovered any new and useful art, machine, manufacture or composition of matter or any new and useful improvement thereof . . . may . . . obtain a patent therefor." In this statute, changed by the 1952 amendment, "process" is now substituted for the word "art."

Criteria for Validity

These three words, "invented," "new" and "useful," measure the right of an inventor to patent protection for his discovery. In a lawsuit last year before the Federal Court in Texas, the role of these three terms clearly appeared.

A manufacturer for a number of years had been producing a housed opaque picture projector in which a pointed arrow was thrown on a screen as a substitute for the pointer long used by speakers in designating objects on the screen to which they referred.

The patent specifications as detailed by the court were, "A complete housing of lights and reflecting mirrors and a bed upon which the opaque object is placed for projection, and an outside knob for the operation of the pointed arrow to follow the object as it is thrown upon the screen."

This invention had been exhibited in Chicago in 1950 and six months later one of those to whom this invention had been displayed undertook the production of the same apparatus, merely substituting a dot for the arrow of the inventor.

The action for infringement was met by the usual defense—the invalidity of the patent. In its decision the Federal Court said of these essential features, the three key words of the statute defining the right of an inventor to a patent.

"The subject matter of a patent must be new and useful. It must call for the exercise of an inventive or creative function of the mind as distinguished from the mere exercise of knowledge and judgment expected of those skilled in the particular art. This is true whether the invention claim consists of an entire machine or improvement of a machine or a combination of several mechanical powers. Patent rights of this sort are given to inventors of some new and useful machine or some new and useful improvement thereof."

This the court supplemented with a comment on the interpretation of the essential in the statute that the invention must be "new."

"Changes of shape or form to produce new inventions or results must be patentable but patentable novelty includes more than mere changes of prior inventions, since the changes must amount to invention. Mere novelty of form is in-

sufficient. Novelty may reside in the arrangement or combination of old elements whereby an advantageous result is accomplished."

Then of the defense that the invention on which this infringement suit was based had been anticipated by an earlier discovery the court added,

"Anticipation prevents invention if before the date when the patentee made it. Such invention may consist of prior patents or publications and it is of no consequence that the patentee made the invention of his own efforts and thoughts and in ignorance of the prior invention of another, since prior invention is what controls."

An action in the Federal Court in New Jersey a few years ago involved the validity of a patent relating to radio receivers. In its decision that here there was no patentable invention but merely an aggregation of elements "each old and each functioning in their well known orbits of influence," the court referred to the authority of a ruling of the United States Supreme Court in which a patent for the improvement of protective devices for electric cable joints was denied validity.

"The fact that the combination without it was old does not prevent invention by the addition of a new and useful element," said that court, "but the addition must be the result of invention, not the mere exercise of the skill of a calling and not one plainly indicated by the prior art."

Improvements Not Necessarily Invention

The validity of a patent on a slide rule was challenged a few years ago in an infringement suit. Holding that patent invalid as neither novel nor an invention, the court outlined the distinction between improvements and patentable discoveries.

"An ordinary carpenter's square is nothing more than a right angle piece of steel with calibrations inside and outside of each arm. The same is also true of other common tools such as the plumb, the level and the compass, going back to the days of the building of King Solomon's Temple. So it is with the slide rule."

"It is a marvellously ingenious basic invention but it has been in the public

(Continued on page 55)

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C. G. McPROUD

Combining business with a vacation, the "Party Trip to England" visits factories, castles, the Radio Components Show, the British Industry Fair—and both banks of the Seine.

ON THE TENTH of April 1953, the sun was shining brightly over New York International Airport—but all the sunshine was intercepted long before it reached the rain-drenched aluminum eagles waiting to be loaded. But the spirits of the sixteen members of the "Party Trip to England" were not dampened at all. Arranged by Leonard Carduner of British Industries Corporation in the United States and Richard Arbib, H. V. Slade, Harold Leak, George Marriott, and G. A. Briggs—all of England—the trip was a delight from the first meeting at the airport until the entire group was back home again.

Getting together with others in the industry is the basic reason behind all the shows, Audio Fairs, and other gatherings of those who participate in the audio business, but it is not often that we are able to meet more than one of two of our opposite numbers from other countries at the same time. Recognizing this, Mr. Carduner—Leonard—fathered the idea that it would be good for everyone if we actually made an effort to be good neighbors—even though we were three to six thousand miles

apart normally. On this premise alone, the trip was a complete success; judged solely as a vacation, it would be rated as equally successful. In England, our hosts regularly referred to us as "Our American Friends," which undoubtedly contributed much to the feeling of good fellowship throughout the trip. We only hope that our hosts and many others we met on the trip will consider themselves our British friends.

Take-Off Day

On the afternoon of the aforementioned April 10, four people from Los Angeles, six from Chicago, and six from New York—along with a few well-wishing friends—foregathered in a small private room at the airport to get acquainted and to get in the proper spirit for an overseas trip. After a suitable interval, they went aboard Pan American's President Special—the actual boarding being interrupted long enough to take the picture shown on this page. Upon arrival at London Airport around 11:00 the next morning, the group was met by Dick Arbib (Multicore Solder) and a fleet of cars which delivered every-

one at the Dorchester Hotel. Following an afternoon's rest and a big and excellent dinner, the party broke up for that day. But only long enough to catch up on sleep, for bright and early on Sunday morning, the cars appeared and provided a day's sightseeing which concluded with a visit to Harold Leak's home and dinner as Mr. Arbib's guests again.

Monday morning was all for sightseeing again, with lunch and dinner as guests of Hector V. Slade (Garrard changers), interspersed with a very thorough inspection trip through the two Garrard plants at Swindon. Tuesday—except for a short evening party as G. A. Briggs' guests—Wednesday, and Thursday were given over to the Radio Components Show—the tenth annual affair given by the Radio and Electronic Component Manufacturers Federation. The men were guests of the RECMF for Tuesday's lunch, and again of Multicore for Wednesday's, after which we went out to Wembley to visit the research laboratories of General Electric Co. Ltd., for a inside view of two of its specialized departments and a demonstration of a new metal-cone loudspeaker which was shown monaurally as a single unit and binaurally using two groups of three speakers each with tape-recorded material and with a live program which originated in a small studio elsewhere in the building. This observer, after coming to conclusions as to the relative positions of the various instruments, made a quick sprint to the studio to see if the orientation was like it sounded. Except for the fact that the violinist was on the opposite side of a ribbon microphone from the other instruments located near it, the position was exactly as it had been pictured in the mind. After tea—a daily occurrence in England, of course—we took another trip to an old (1135 A.D.) inn on the Thames for dinner as the guests of GEC's George Marriott—the ladies having joined us *en route*.

Thursday was spent in further visits to the Components show—followed by the Grand Ball on the concluding night of the show. To Paris by plane the next day, and a few days spent in sightseeing, followed by the writer's visits to audio spots of interest which included the radio studios, the Audax plant to hear the Ionophone, Film et Radio to hear the Focalizer Baffle, and the offices of the French radio magazine *Toute la Radio*, where we met Editor Aisberg; and later to Editions Chiron where we met Georges Giniaux, publisher of *TSF et TI*, *L'Onde Electrique*, and



They're off! Left to right: C. G. McProud, Mrs. McProud, Adolph Gross (Pilot Radio national distributor) Mrs. Gross, Sam Poncher (Newark Electric Co.) Clancy Nystrom (Kierulff, Los Angeles), Mrs. Poncher, Leonard Carduner (British Industries Corp.), Mrs. Nystrom, Mrs. Carduner, Harry A. Lasure (Mfgs. Rep., Los Angeles), Mrs. Lasure, S. I. Neiman, (Int'l Sight and Sound Exp'n president, Chicago), Ken Prince (Parts Show entrepreneur, Chicago), Mrs. Neiman, and Mrs. Prince



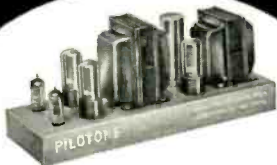
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At the RECMF show—left to right: Ken Prince, Adolph Gross, Richard Arbib of Multicore Solders, Sam Poncher, Leonard Carduner, Clancy Nystrom, "SI" Neiman, Harry Lasure, and the writer.

the new sound magazine *La Revue de Son*, which made its bow with the April issue. For an interesting dinner some time, try being the guest of a French publisher who speaks only a few words of English (assuming you can speak less than half that many words of French), and an interpreter who speaks both. To make it interesting, add two wives—one who speaks only French and one who speaks only English. Such was our experience with M. Giniatux, but we all made out satisfactorily, with relatively little misunderstanding.

Temporary Breakup

On Tuesday April 21, the party broke up for a few days—some went further east to Rome and Switzerland, some stayed in France, while the writer returned to England for a short motor trip through the south counties, returning to London the following Monday. Tuesday was devoted to a visit to the plant of Goodmans Industries, Ltd., in Wembley, and to a farewell dinner given by the Carduners at the Savoy. Most of the group left England on Wednesday, but this observer felt there were still a few things that should be seen, such as the EMI studios, the BBC studios, the Tower of London, the British Industries Fair, and the changing of the guard at Buckingham Palace. In between, we were the guests of the Radio Industry Club, which meets monthly, and of a few other British friends at various events. Among these were H. A. Hartley, whom we had met at various Audio Fairs in New York; Andrew Reid, press officer for the Radio Industry Council from whom we have received many communications and British Radio Standards; William T. Ash, RECMF Secretary; H. F. Smith and Hugh S. Pocock, editor

and managing editor respectively of *Wireless World*; and H. G. Foster, managing editor of *Electronic Engineering*. The ease in making friends in England indicates that if we were to stay long enough to spend a few hours with each we would be there forever.

Impressions from England

Differences in manufacturing practices in England and in the United States appear to be the result of the differences in the economies of the two countries. While the U. S. practice is to "farm out" as much of the construction work as possible—at least in many plants—the exact opposite seems to prevail in England. Garrard, for example, makes all the individual "bits and pieces" used in the assembly of its record changers—including such specialized units as the motors. Laminations for both rotor and stator are punched out, assembled, and mounted to complete the motor; the large panel for the top assembly is punched out and shaped, turntables are stamped, all of the various intricate parts are made—with close quality control—in the same plants. The same condition obtains at Goodmans, where all the loudspeaker punchings and stampings are made, and where even the cones are made right in the speaker plant. The differences in U.S. and British manufacturing processes were particularly noticeable in these two factories.

Interest in audio is well developed in England, but, again because of the difference in the economies of the two countries, there has not yet developed the wide public interest that is prevalent in the U. S. Those who have a highly developed sense of interest in audio are serious and very quality-conscious—perhaps even more so than here, but there are not so many of them.

A rather large number of tape decks made their appearance at the RECMF show—most being in the category of the medium-priced U. S. models; the EMI equipment rivals the finest produced here, and for original recording these machines are still being operated at 30 in. per sec. Workmanship appears to be uniformly excellent, especially with mechanical assemblies. While we are accustomed to a certain range of control-knob varieties in this country, we noted another range—entirely different—on British equipment.

The French Picture

One of the principal reasons for visiting Paris—aside from the better known ones—was to see and hear the Ionophone, which has received so much glowing publicity in the popular press. In our opinion, this equipment undoubtedly provides an efficient method for coupling ultrasonic frequencies to the air, since it is claimed to work well up to 100 kc. However, as a speaker in the higher audio ranges—say, from 300 to 20,000 cps—we were not impressed, especially considering the equipment required for its operation and the continuous power consumption of around 50 watts. As is well known, this power is fed—as r.f.—to the unit to ionize the air, the modulation being applied to the oscillator unit. The hiss that was noted by earlier observers has been eliminated in the more recent models and is no longer a disadvantage. But it remains the opinion of the writer that for audio use—as a tweeter and/or super-tweeter—the Ionophone offers no advantages over a high-quality dynamic reproducer, and that it has the disadvantage of higher initial cost as well as a continuing operating cost.

The Focalizer Baffle—previously mentioned in these pages at times—is also viewed with mixed opinions. Constructed, in its present form, of staff—but realizable in molded plastic in large quantities—this unit can be made with almost any desired directional pattern. For many applications, this would present a considerable advantage, where, it was desired to provide sound coverage over a limited area, for example. However, as a single-unit high-quality speaker, it does not appear to have adequate low- or high-frequency response.

Broadcasting and Recording Studios

Several interesting hours were spent in visiting the studios of Radiodiffusion Francaise, the British Broadcasting Corporation, and EMI—which does the recording for many of our imported labels. One outstanding difference noted in Paris was the use of cream-colored equipment. Racks, panels, control consoles, and tape and disc recorders were all of a pleasant cream color—providing somewhat more light in operating quarters. Studios were decorated in a pleasing manner—with suitable and interesting ornamentation—and in many instances arranged so as to provide for controllable acoustics within the same area. One studio was equipped with a

(Continued on page 62)

SPECIALIZATION MAKES THE DIFFERENCE

Specialization may be defined as the concentration of all effort to a special or specific course of action

Even a mechanical device concerned with the function of record reproduction should possess all the advantages of such specialization.

Most units undertake to do much more. They change records, mix records, flip records, reject records, and assume a multitude of other functions. This is 'generalization' as distinguished from 'specialization'.

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Equipment Report

LEAK TL-12 AMPLIFIER with VARI-SLOPE CONTROL

ONE OF THE FEW amplifiers to be equipped with any means for varying the slope of the treble roll-off obtained by the use of the high-frequency tone control is the Leak Vari-Slope preamplifier, which was studied with the Leak TL-12 triple-loop "Point One" power amplifier. Both sections incorporate some interesting features which differ in design principles from most American circuits. The Leak amplifier, as is well known, is British built.

The preamplifier employs only one tube—a dual triode. It is equipped with type ECC81, which is replaceable with the American 12AT7. All inputs are channeled through both stages of this tube, with differing amounts of feedback over the first stage being employed to adjust for the different input-signal levels. The input

selector switch provides one position for high-impedance microphone, three positions for phonograph with equalization for magnetic pickups, and one position for radio. Input voltages for one watt output, with the gain control at maximum, are .001, .003, and .010 volts, respectively. This is somewhat higher sensitivity than required on the radio channel where a voltage divider may be required to permit satisfactory operation of the volume control, or at least to balance the tuner and pickup levels approximately.

The phono positions of the preamplifier provide a bass turnover of approximately 400 cps (it differs only slightly between the three positions) and a choice between flat and roll-off response. The LP and 78A positions are uniform, with a 15-db drop

at 10,000 cps; 78B is essentially flat on the high end. The tone controls operate in steps, and serve to vary the inflection point on both bass and treble ends. The Vari-Slope feature provides a range between 5- and 50-db per octave roll-offs above the high-frequency inflection points, which are 9000, 7000, and 5000 respectively. The slope control has no effect on the boost positions, nor upon the bass control. Measured curves are shown in Fig. 3, page 54.

The control unit is easily mounted on panels not exceeding 34-in. thick in a cut-out $3\frac{1}{2} \times 10\frac{1}{4}$ in. When it is desired to operate the preamplifier as an integral part of the power amplifier, it may be attached to predrilled holes on one end of the amplifier chassis, electrical connections being made with a short cable which is obtainable as an accessory.

The power amplifier is of a design which has not been publicized appreciably. It consists of a pentode first stage feeding a "long-tailed pair" of triodes (in a single envelope) which drive a pair of pentodes which are separately cathode biased. Tubes employed in the first two sockets are 6F-36 and ECC-33, which may be replaced by 6J7 and 6SN7 respectively. The output tubes may be replaced by 5881's or 61.6's if the specified KT-66's are not at hand. The over-all feedback loop covers all three stages, and is fed from the secondary of the output transformer. The secondary may be connected so as to provide impedances ranging from 1.7 to 36 ohms.

The Leak amplifier has long claimed distortion figures below 0.1 per cent—hence the name "Point One"—which are borne out by measurement. Intermodulation distortion is less than 0.3 per cent at normal operating levels. Despite the unusual connection of the output stage whereby the two tubes derive their bias from independent resistors, no change in either output

(Continued on page 54)

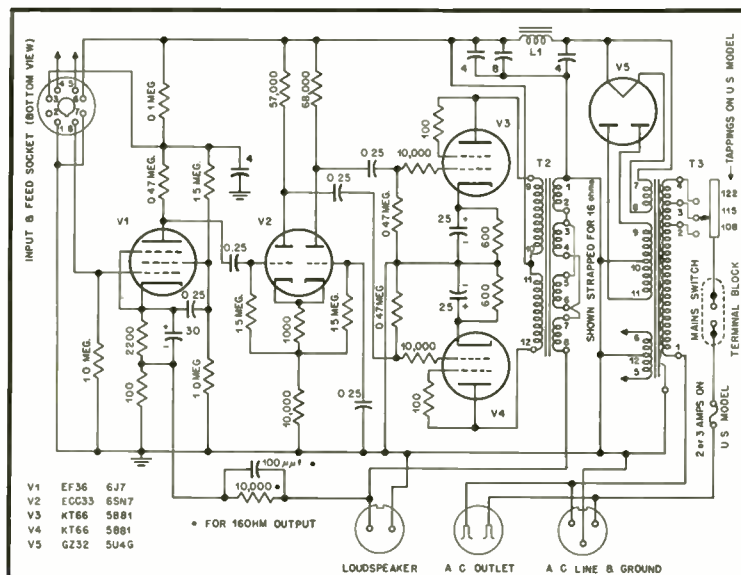
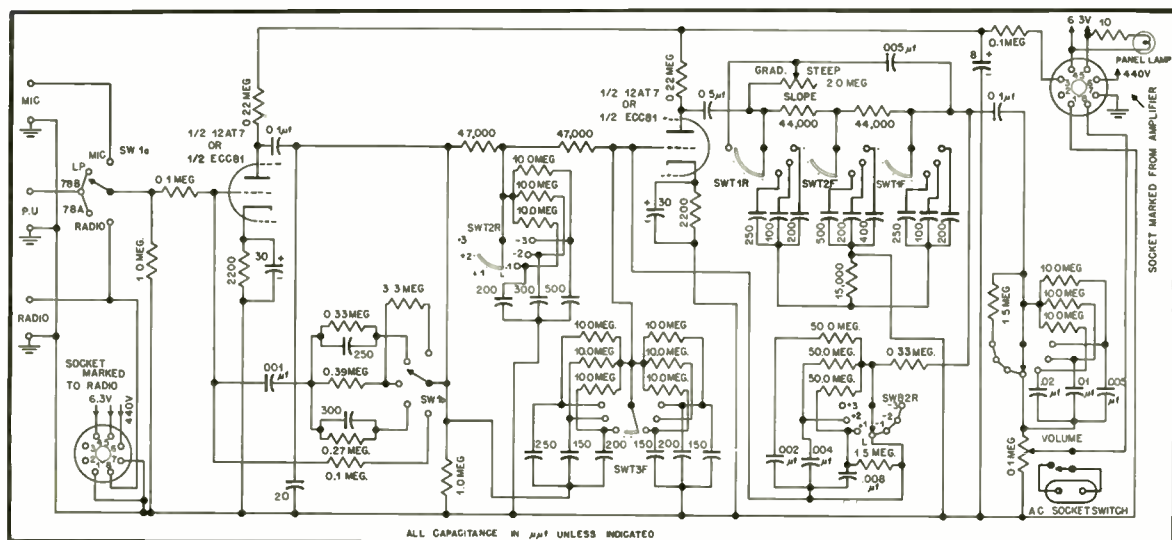


Fig. 1 (left). Schematic of Leak TL-12 amplifier and power supply. Fig. 2 (below) Schematic of Vari-Slope preamplifier.





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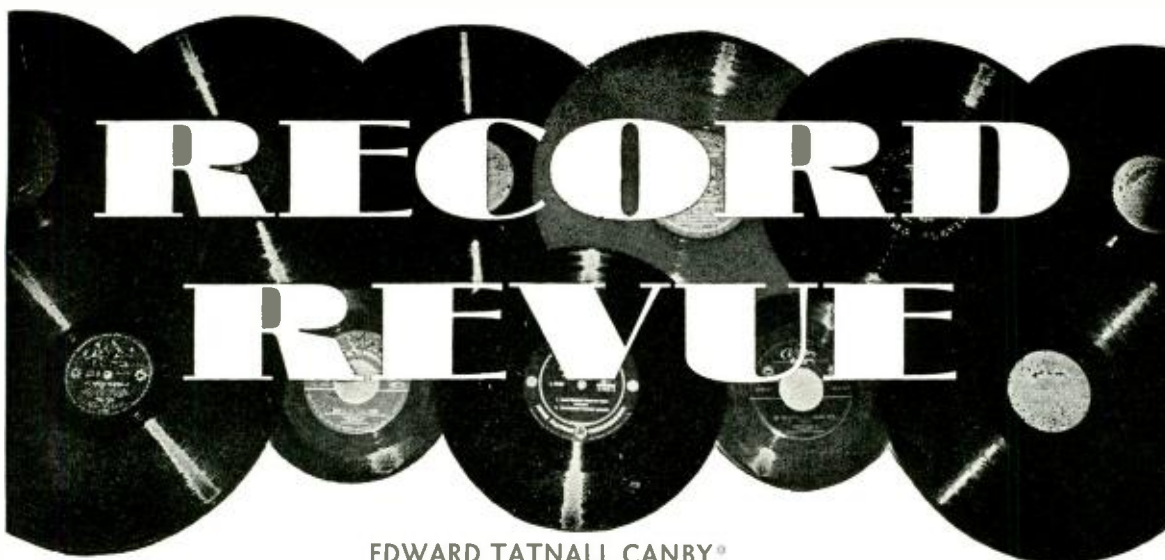
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RECORD REVUE

EDWARD TATNALL CANBY*

I'VE JUST BEEN audio-visualizing a couple of Beethoven violin sonatas, thanks to the Decca company. The solid album, reviewed on page 48, in which the complete set of ten sonatas for violin and piano is issued contains not one, but two equally important and complementary recordings of the music. Five plastic discs constitute the audio record. Forty-odd shiny pages of musical notation in an album-sized booklet constitute the complete visual record. These two, between them, are the present-day essentials in the preservation of that nebulous thing, the original work of music—which of all forms of human expression is the most transitory, an intelligence that is of the moment, gone with each instant of living performance.

Music is preserved in another way, too, passed on from one artist to another as a living tradition. Folk music has always been so. Composed music, more than most of us realize, depends very largely too, upon the audible passing-on of the ways of performance from one person to another, by imitation and embroidery. But this endless chain of shared experience is *not* a recording. It operates fluidly, with freedom, the shared experience shifting, changing, growing, ebbing, according to its passage from one person and one group to another.

This is the process of legend, of folk lore, and it is a vital thing in human life—but it is, again, no *record*. We all remember the children's game where a message is passed by whispering from one child to the next around a large circle—to emerge fantastically garbled at the starting point. We all know the power of gossip and the unreliability of the eye-witness, after the fact.

Until recently, there was, then, only one way in which music could be exactly preserved even in any aspect of itself. Since the Middle Ages, music has been "coded" into those complex hen tracks we call notes, and with a remarkably good level of accuracy. One cannot measure it mathematically, but I would suggest a figure of 20 per cent for our very early written music, perhaps 60 per cent for the age of Bach, in the 18th century. That is good—since notes are *not* music itself, but a mere coding of the gist of music.

By the time we get to Beethoven, in the last century, the power of passed-on aural

Keeping the Score—I

tradition becomes more immediate. We have a fairly good idea of the actual sound and the expressive intentions of such music. Our musical elder statesmen have heard famous performers who, in turn, had heard those who were alive in the time of Beethoven. Even so—we cannot rate today's Beethoven at anywhere near 100 per cent as a record of the original, even including the known traditions along with the cryptic code. A high figure would be 85 per cent for the aural tradition plus the written notes.

The Visual Library

Music has been preserved in the coded form for roughly a thousand years in recognizable modern notation. The library of music is an august and awesome collective institution, second only—in the way of codes—to the still greater and older library of written-down language. Printed music, new and old, thus has the sanction of centuries of scholarship and of the composing art. In its vastness of organization it is nothing less than one of the very rocks upon which the knowledge of the continuity of our Western culture is founded. A priceless heritage, as the old saying goes. It's hardly surprising that for many an expertly trained musician, many a collector and many a trained librarian, the printed music *is* music itself. And yet the plain fact is that it is not. Nor, today, is it the sole infallible means of preserving the thing itself—the audible art.

Platitudes? Sometimes things are so obvious that we don't see them. I don't think enough of us realize the significance of the audible recorded sound as a record, it is so new in the face of the ancient and established visual method of recording. I am not for an instant suggesting that printed music should be thrown out of our thousand-year libraries, and plastic discs filed away instead! But I cannot help feeling that, after a thousand years of the visual system, we have come to place somewhat more emphasis on the sacredness of the printed note than is called for. Musical notation remains, for all our scholarship, a code, and a highly ambiguous and flexible one at that, in more respects than most musicians like to admit. That is no criticism

of the "system"—for music is by nature, by its very need for constant re-creation, a flexible and adaptable art. Nevertheless—a code it is, this notation.

We must, then, learn to treat our present two methods of musical preservation as equals—unlike equals, complementing each other. There is a tremendous need for our professional musicians and our music librarians to accept the audible record on a par with the visual, so that a beginning may be made towards working out a systematic filing and working method that can equal the international book-library visual systems that have developed over centuries. Musicians, librarians, and teachers especially, must learn to value the audible record as highly, in its place, as the visual record. That is far from the case in many areas of music right now.

The Audio Listener

But—and here we come to a perhaps unexpected point—what of the other side of the coin? There are vast numbers of music listeners today, many of them highly skilled in their knowledge of audible music, of performance values, styles and taste—genuine connoisseurs in plain fact, who nevertheless have not the slightest knowledge of the musical coding system, and profess to want none of it. Recently the hi-fi fraternity (as it is more and more commonly called, in a derogatory sense) has especially distinguished itself by its ignorance of the one method of preserving sound, in favor of a highly technical knowledge of the other method. I am here to suggest, then, that the hi-fi hobbyist and the recorded music enthusiast alike should learn the fundamentals of the *written* musical language—for their own higher enjoyment. I am here to congratulate Decca for its superb dual Beethoven recording—offering both kinds of musical record in the most convenient and economical form that each can assume. Also Westminster, for similar dual recordings of the Bach English and French Suites for harpsichord, and several other companies who have already released, or plan to release dual albums with recording and musical score. A fine idea. We all should follow scores.

But how? It would be scarcely cricket for me to "cease fire" at this crucial point, having delivered my sermon on the moral

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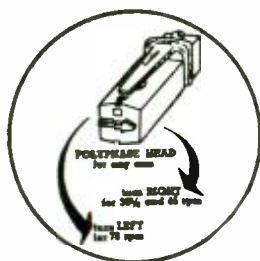
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obligation we all have to learn to follow musical notation!

Four Ways to Read Music

First of all, get it clear in your mind that there are four ways in which musical notation may be read; you will be involved in only one and that by far the simplest.

(1) Musical sound may be directly produced by first reference to the score. This is active reading. Actually, sight-reading—the translation at first sight—is relatively unimportant and seldom produces real music, except from a few near-geniuses who can get a maximum of sense and execution simultaneously at the very first look. Most sight reading, even when it is technically correct as to pitch and rhythm, is soulless and unmusical, because the real sense of music must be felt and understood before it can be played intelligibly. Sight reading, therefore, is used widely in music as a derogatory term—"mere sight reading," is very acid criticism.

(2) By far the more common use of musical notation is as a reminder, a prompter. Thus, after adequate rehearsal—many playings and much study—an orchestra player "reads" his part at a concert, following it exactly, but with a foreknowledge of what is to come that usually keeps him mentally well ahead of the actual music. When a page is turned suddenly, your concert performer can usually go on for a good distance before his memory-of-the-moment fails him. This sort of reading extends all the way from the end of sight reading to the beginning of straight memory work. It is the largest direct usage of the printed note.

(3) There is an elusive sort of reading that produces music only inside the head of the reader, without outward sound. This sort of reading is hard to assess because it is seldom outwardly put to the test; many a musician picks up a score, casually looks it over and announces, "yes, yes—quite interesting," or a suitable variant; how much actually does he hear? An interesting question.

It's surprisingly easy, with practice, to get a good idea of the general style and sense and even sound of a musical score without hearing the tones in their exact pitch relationship. (Rhythm is easier, on the whole.) One can even judge, to some extent, the worth of a piece of music in this fashion. This is entirely legitimate. But, since it's not easy to challenge this kind of reading, a lot of cocksure people get away with impressive murder, sometimes not even consciously. They think they are hearing the music, inside.

Many of us can hear written music with reasonable accuracy but not necessarily at its correct absolute pitch. A few experts can go so far as to pitch the music unerringly, simply through vast experience rather than any inborn special sense of absolute pitch. I'll have to say, modestly, that on occasion I can do this—hit the right pitch. I don't have absolute pitch. Instead, I am familiar enough with the sound of some types of music to be able to reproduce in my mind even the proper pitch of the notes, as printed.

As a choral conductor I know that a leader can rehearse a strange piece with only a slight knowledge of its sound beforehand. The instant the actual sound begins to come forth in reality, such a person can jump far ahead of the individual performers and keep ahead throughout the study process. That applies to conductors of orchestras, too—not to the big ones, but many an inexperienced beginner, who gets

his start by this sort of quick mind and clever bluff.

(4) Finally, there is the extremely simple kind of score reading that consists merely in following the printed music as someone else plays it. That is the kind that is of importance to listeners of audible recordings. It involves an absolute minimum of technical understanding. The music is played for you and the only "mistake" you can make is to lose your place! The work is nine tenths done for you, but the pleasure and detailed knowledge of the music as it progresses is equivalent to the satisfaction had from a good map of a strange city or a floor plan of a large building. You can see where you are and how things are organized, as they appear before you. The eye, in music, thus aids the ear in assembling the large audible time-picture.

I propose to do here, from time to time in future issues, what is perhaps a bit novel in a periodical of this sort, give some specific directions as to score reading. Let's begin, briefly, with the following:

Pitch and Rhythm

The two basic written-down elements of musical notation are pitch and rhythm. Both depend on mathematical relationships that are largely relative—i.e., they are proportions. There is an element of fixedness in pitch, but it is occasioned mainly by the needs of the instruments; it is not an essential of music; for a work of music is recognizably the same even when the entire pitch is changed—so long as the relative values remain constant. In pitch, these values are frequency proportions. The same is true with rhythm. There is a roughly "right" speed for any work, but if the inner time proportions remain constant, the music may be slowed down or speeded up and still remain quite recognizable.

These basic relativities have directly to do with the latitude of musical interpretation that we know is accepted in the musical world. The score itself is rigid and must be so by its nature. But the music made from it may vary in many ways, yet still remain within the reasonable bounds of performance.

Two basic assumptions must be made in order to write down music—and it took many centuries of thought before these obvious concepts were worked out.

(1) *Pitch* must be conceived of as *lying in a vertical plane*. A progression towards faster frequencies ("higher") is up, towards lower frequencies is down. This assumed relationship is so graphed on paper. (A similar conception, equally arbitrary, is the idea of "north" in a map. Note that we speak map-north as "up" or at the "top" of the page, when actually the top may be facing south.)

(2) *Rhythm*, the time relationship in music, must be conceived as *extending from left to right*, right being towards the future. (Another simple idea that, however, took whole ages of time to develop before writing could be perfected.) The vertical plane equals simultaneity, in this respect.

Given thus much, as anyone can plainly see, the creating of a score—and the reading of it—is basically a matter of dividing up the page in two dimensions to correspond to the patterns of the music. One reads rhythm somewhat as one reads printed words, progressively from left to right. One reads the associated pitch (or recognizes it as it is being played) by the vertical position, up or down, of the printed notes. Simple!

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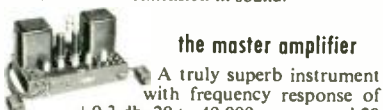


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wanted, are all taken care of within this framework. Words, when used, are added in the proper time-spaces. For the rest, all sorts of subtleties of language and coding take care of that 20-to-85 per cent accuracy that I've already suggested as optimum in notation.

* * *

With only this much knowledge—and many readers know a lot more—you can follow a printed score without too much trouble, or learn to follow one by simple direct observation allowing the sight and sound to reach you simultaneously. I'll go on, in a later installment, to give more specific information for those who wish to use it.

RECORDS

Beethoven: The Ten Sonatas for Violin and Piano. Joseph Fuchs, violin; Artur Balsam, Piano. Complete miniature score included. Decca DX 150 (5)

A monumental and well executed job, this, though not what I would call a display of super-brilliance. The performers are first class, especially the excellent Fuchs, but they do not reach the peaks of excitement and emotional intensity that, for example, the memorable team of Busch and Serkin could manage. No matter; these players are more accurate and, over such a long stretch, decidedly preferable. (Busch was highly erratic and even Serkin could scarcely sustain his best intensity for so long.)

Recording, in my copies, is variable, from fairly good to very good. The best seems to be the disc with the famous "Kreutzer" sonata, plus the short first sonata; some of the others seem less clean and sharp and at least one—thanks to Beethoven—puts too much on an LP side, with consequent distortion at the inner grooves. Violin is close, piano at a little distance, but the blend is acceptable. Decca's surfaces remain erratic.

The included score, a reprint of a reprint of an authoritative German edition, is a superb addition, especially for this music which, with its two clear-cut elements, is unusually easy to follow on the printed page. For those with even a bit of piano under their fingers, the pleasure in hearing and seeing is great—how smoothly and competently those complex masses of notes come forth, as the pages turn.

Borodin: Prince Igor. (Acts I, II, IV). Russian soloists; Chorus and Orchestra GABT of USSR. Russ-Engl. text.

Period SPL 552

If you have enjoyed the familiar "Polovtsian Dances" music—or if you find Russian singing and Russian opera exciting, you'll be curious about this, among numerous recent Russian operatic offerings. Well worth its cost, if you don't mind some distortion in the sound; but it won't do for hi-fi fans, that's my verdict.

More specifically, the music is that blend of the lilting and tuneful and the dark, solid Russian folk music that one might expect from this school. More lyric, less rugged than "Boris Godunoff" of Moussorgsky, but far more sincere and likable than the slick stuff of Rimsky-Korsakoff. The Russian voices here are as good as they usually are, which is extremely fine, notably the two bass-baritones in leading roles.

The distortion is almost entirely the sort which is due to overloading, somewhere along the recording process. The softer parts are nicely clear, with acceptably wide tonal range, but at the slightest suggestion of climax the sound goes into a tail-pin of unpleasant confusion.

Why, I wonder, is this often a characteristic of Russian recording? Is there an engineering generalization that might account for it? Same thing is true with Vanguard's recordings of Prokofiev and Shostakovich cantatas, recently issued.

The Russian text is printed in Western letters a procedure I haven't seen before. Wonder why. If you know any Russian you can read it. Good answer: you can at least follow the spoken words phonetically in this way, understanding or no.

Mahler: Das Lied von der Erde. Kathleen Ferrier, Julius Patzak; Vienna Philharmonic, Bruno Walter. London LL 625/626 (2)

I have not heard the rival Vox version of this, but here, at least, we have the greatest of Mahler orchestral interpreters. Walter, plus the contralto of his own perennial choice and a leading German tenor, plus a beautifully clean and golden firm recording. That makes it a top job, though there are some interesting reservations to be made. I'm still not convinced that Ferrier is the ideal Mahler singer, with her so-so diction, though she is certainly a great artist and well suited to these philosophic songs of tragic resignation. Patzak is not a strong tenor, though lyric, and his performance is unsteady here with some muffled high notes.

What is of special interest to the technician is the extraordinary balance between the solo singers (who alternate in the seven songs) and the large orchestra—for here, apparently, is an attempt to restore the literal concert hall balance of loudness that is so seldom heard in today's close-up recordings. In place of the expected loud solo sound, these two soloists are surprisingly faint, rising to good volume in their loneliest passages but almost inaudible in the midst of the orchestral sound when their notes are less than forte.

Strange—because it is so unsatisfactory, even though this is surely very close to the balance that might be heard from a concert hall seat. The reasons are not hard to pin down.

The ineffectiveness of these literally miked solo voices is partly due to association—we have become so familiar with the prevailing close-up techniques, using solo mikes for selective amplification of the solo, that we cannot immediately adjust to this thin vocal sound, 'midst the huge orchestra.

But there is a deeper reason. This is a monaural recording. The monaural medium cannot afford to lose immediacy and direct contact with the soloist to the extent that is possible binaurally in a concert hall—with the aid of the two teamed ears and the visual sense.

In concert we hear with two ears and see with two eyes. Reduced to the monaural situation, with but one recorded channel and no eyes, the stage sound of a solo voice is too faint, too out-of-touch. We must necessarily resort to the synthetic selective amplification of the solo that is now standard technique. How much of it to use is a nice question—but some there must be. We cannot be literal, in monaural reproduction. (For further study of this interesting question, try RCA's reissue LP of Lehmann in Strauss' "Rosenkavalier," LCT 6005. See *AE*, March 1953)

UHF

The Turntable HF-1 (10" 78 n/groove)

The publisher of this extraordinary new hi-fi disc sent me test pressings, accompanied by a long letter describing the infinite care which was taken in order to produce the finest possible quality—and so enthusiastic was the account, that he completely forgot to mention the musical contents. Nor did the pressings help; the enlightening information thereon consisted of the words TEST PRESSING and not a thing else! Hence the above somewhat cryptic listing. (Also omitted was the groove size and recording speed. I figured that out by the look-and-listen method.)

For your information, the music is jazz (using that term loosely) and it is not only good jazz, to my ear at least, but is extremely well chosen for the purpose—top quality hi-fi reproduction from every angle. The recording is done with exactly the right semi-intimate, close-up warm liveness, and the balance of the several instruments, including piano, percussion battery, clarinet, trumpet, trombone, is first class.

This is more, then, than a technically high-quality disc; it is a true hi-fi recording all over, from choice of material, acoustics and microphoneing right on through. Proof of this is that it will make any phonograph sound its best, including the cheapest home squawk box. I've tried it.

This material represents to my mind an excellent example of the optimum musical sound for the recording medium. It is, of course, strictly "chamber music," played close-to in a relatively small place, no "concert hall" liveness. It is an ensemble of sharply contrasted soloists, each reproduced at the optimum distance for good effect. The same physical principles of desirability apply to other types of music with a similar make-up. Bach trio sonatas, Schubert's "Trout" Quintet (with piano and double bass), Stravinsky's "Histoire du Soldat," Varese's "Ionisation"—to name a few examples. There is much to be learned

about good recording from this disc if you will keep a wide-open mind. Wonderful jazz, too. Wonder who plays it. . . .?

78-r.p.m. microgroove is clearly the coming medium for specialized hi-fi discs. Six or more minutes to a 10-inch side is fine for the purpose. Only practical drawback: groove skipping is more likely than in other media, given slight jarring, but this is not important for the hi-fi specialist.

Goeb: Symphony #3. Bartok: Sonata for Two Pianos and Percussion. Leopold Stokowski & His Orch.; G. Yessin and R. Viola, pianos, E. Jones and A. Howard, percussion. **RCA Victor LM 1727**

An interesting disc of hi-fi material. The Bartok opus is perhaps the most utterly furious work of percussion writing conceived to date. It uses the pianos violently, percussively; its battery of drums, xylophone, and cymbals are used with extraordinarily furious exactitude, the rhythms asymmetric (no two measures alike, much of the music in rhythms of five, seven or violent alternations of primes). The extreme care in which the tiniest details of the score are indicated is matched only by the extreme violence of the result. There is no other work like it, except possibly the related (and milder) Music for Strings, Percussion, and Celesta. Of special interest are the "sliding" kettle drums, which change pitch during a roll, via foot-pedal tighteners.

A striking performance, this, (to use an apt term)—but I don't like the large background "concert hall" liveness. It is not suitable to this 20th century music and merely injects a softening and blurring element to weaken the effect—as the same would do with a jazz trio. This is not Brahms or Wagner!

Other than that, and a slight thinness of piano tone, you'll find no complaint—the percussion, particularly the xylophone and other high percussives, are stunningly good. Not for lovers of old fashioned charm, but those who like jazz and hop and the rest will find this intensely exciting and remarkably "of our day"—for the product of a good Hungarian.

The Goeb symphony, modern American, has much fine brass and percussion writing of a more sonorous kind, well suited to Stokowski's favorite huge liveness. The symphony is no dry work in spite of a lot of noise; it reflects some Hindemith and Copland, is well and linearly written but towards the end falls into what begin to sound a bit like modern clichés. (We've got that far in the modern idiom.) Fine stuff for your system, if you want a change of hi-fi material. Crackly surface.

Grieg: Symphonic Dances, op. 35; Norwegian Dances, op. 64. Danish National Orch., Tuxen. **Mercury MG 10132**

Nicely proper stuff after the preceding Bartok. Melodic, sweet, not particularly "hi-fi" except for some good drum passages. Huge liveness here, and it sounds like a one-mike job at (for our taste) a shade too great distance. Matter of taste. If you like Anitra's Dance and the rest, you'll like this.

Respighi: Pines of Rome; Fountains of Rome. Minneapolis Symphony, Dorati. **Mercury MG 50011**

I don't have Westminster's recent Pines and Fountains with me at the moment; see *AE* for April for an extended discussion of it. This one, as indicated then, calls for the milder and better AES curve instead of the NAB with its very sharp preemphasis of highs. It is interesting to find that, when properly equalized, this version has sharper musical highs—in the recorded sound, quite aside from the recording curve. The difference is undoubtedly in the miking; Mercury's single Telefunken at 15 feet from the podium picks up more direct highs in the tonal coloration. A tricky difference. Many a listener has confused the balance of highs in the original recorded sound with the balance obtained in record equalization or mis-equalization. Might easily think this disc was the more strongly pre-emphasized, but it's not. Westminster's has the sharper high end.

P.S. That nightingale is here again, in the Pines; this one is louder and clearer than Westminster's and so sounds more incongruous and unlikely. Respighi's fault, not Mercury's.

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**Bartok: Dance Suite. Kodaly: Dances from
Calanta. London Philharmonic, Solti.
London LL 709**

Bartok and Kodaly were life-long Hungarian co-workers and are often coupled musically, as here. Kodaly, however, is far more the conserva- tive traditional composer at heart in spite of a good modern tonal palette. Therefore we find here a difference not unlike that between Bartok and Geob on the RCA disc, above.

The Galanta dances, nostalgic and Hungarian in a familiar manner, are beautifully suited to the typical frrr golden liveness (though I will never get to like the too-shiny close-up strings of this technique—that's the way strings sound when you sit too close to them in concert.) But the Bartok, a more powerful and more modern set of dances, is somewhat lost in the very same liveness: it has the feel for a closer, drier space. Before acquiring this, try Peter Bartok's ver- sion; it's hi-fi and as I remember, done with less of the golden acoustic.

**Glazounov: Raymonda; Suite. Paris Phil-
harmonic, Rosenthal. Capitol P-8184**

A beautifully plastic performance of this color- ful and innocuous ballet music, beautifully re- corded—though its instrumental texture is not particularly of the hi-fi sort. Sounds like an- other one-mike job, at an even more pronounced distance than the Grieg recording from Denmark, above. Wholly appropriate in this case; the music is big, romantic, intended for public display in the ballet tradition, and goes perfectly into this pleasingly live sound environment.

**Bruch: Violin Concerto; Kol Nidrei.
Michele Auclair, violin; Austrian Sym-
phony, Loibler.**

Remington R 199 27

A soft, amiable, feminine work of violin Ro- mance, and this performance is warm and aimable itself. The lovely Michele Auclair is nicely suited to the music though I'd say her tendency to slide once and awhile goes beyond the need of the music—it's not that sentimental. (Similarly in Kol Nidrei she tries awfully hard to sound un- fathomably Hebrew in the opening lamentation of the traditional chant.) This is the kind of music where the orchestra is no more than a fine, in- spiring fuzzy background and Remington has placed it exactly right in the recorded balance. A nice, soft sound, with indifferent highs, where sharp, steely highs would be musically out of place anyhow. Good.

Remington's present surface is almost silent and very free of irregular ticks and bumps. For most purposes you can discount it entirely as a dis- turbing factor. The low prices now about match those of the Columbia Entre, RCA Blue Bird, and similar "second" lines.

MUSIC WITH CELLO

**Beethoven: Cello Sonatas Opus 5, #1 and
#2. Antonio Janigro, Carlo Zecchi, pf.**

Westminster WL 5170

**Beethoven: Cello Sonata op. #69; Vari-
ations on Mozart's "Bei Mannern". Janigro,
Zecchi. Westminster WL 5173**

Four excellent sides of Beethoven in his cello expression. This is a tough combine for record- ing; piano sound is hard enough to get onto discs but the cello is nicely contrived, unfortunately, to cover the tonal area where the most trouble- some acoustical resonances occur in most phono- graph situations. Its middle tones set small cabi- nets buzzing, its medium bass may hit off unpleas- ant peaks in bass reflex speaker cabinets and oth- ers that tend towards resonance—and the lowest cello notes are ideal for setting up huge stand- ing waves in small to medium listening rooms. Thus many a cello in recorded form sounds more like a double bass in a juke box.

Westminster's big liveness makes this cello- piano combination sound huge. Good highs miti- gate the relatively bassy sound of the instrument; on really good equipment it should come through beautifully. But these are fine discs for energiz- ing your resonant peaks and some experimenters may be inclined to blame the recording. Blame that last—the room comes first, the speaker en- closure next in likelihood, along with loose boards, chinaware, etc., even such unlikely annoyances as tone arm or motor board resonances may be touched off by the potency of rich, low cello tone.

A useful kind of test record for your over-all system-in-action—listening room included.

Virgil Thomson: Suite from "The Mother of Us All"; Cello Concerto. Luigi Silva; Janssen Symphony of Los Angeles, Janssen, Columbia ML 4468

An interesting phenomenon, Mr. Thomson! He is our very best music critic and a penetrating analyzer of musical style and content in many an ultra-modern idiom as well as the older traditions, yet his own music is remarkably consistent and comfortably conservative—if that is the word for music which uses harmonies sometimes about as complex as a good gospel hymn, yet manages to hit a modern feeling even so. I find him more pleasing in the "Mother" music, built largely on gospel-hymn and old-fashioned American musical slang, than in the more pretentious cello concerto, which must necessarily, as a concerto, take on some of the concert hall conventions of virtuosity and "highbrowism."

This cello is noticeably thinner, less bassy in tone than the Westminster and for good reasons. It is heard as an orchestral solo, and so is properly at a distance and relatively thin sounding. The Beethoven sonatas are properly more close. A cello in an orchestra and a cello in a small room are two utterly different instruments to the rightly placed listening ear.

Schubert: Trio #1 in B Flat. Jean Fournier, violin, A. Janigro, cello, P. Badura-Skoda, pf. Westminster WL 5188

This is one of Schubert's most infectiously light and melodic works, with a wealth of fine rhythms, catchy bits of tune, superb high treble piano. The performance is not as lightfooted as some, though it is highly musical, and the same big liveness as the cello sonatas above perhaps adds a trace of elephantism to the music. For many listeners this "bigness" will please, since it mitigates the "chamber music" sound, but the fact remains that the music is not big, pompous stuff by nature. It needs a thinner, more intimate acoustic.

Interesting technical point here: this is evidently one of Westminster's RCA pressings. Most discs from this company are Columbia-made, with the sharp NAB pre-emphasis; but the RCA items, as I understand it, have a different curve with less sharply boosted highs, nearer the AES curve—or perhaps the "New Orthophonic." The difference is immediately noticeable on this disc. You'll need less roll-off of the highs, to match it to the similar sound of the Columbia-pressed cello sonatas above. (Columbia-made Westminsters have an "XTV" in the imprinted master number on the disc face.)

Some day we'll have just one nice, broad curve for all LP records. When?

American Folk Music, vols 1, 2, 3 (2 LP's each). Folkways Records.

Don't miss this enlightening and amusing reprint series. Each LP contains 14 ancient 10-inch record faces, copied (and very nicely) from discs issued back in the very earliest days of electrical recording. The variety is amazing, the musical content varies from negligible to significant, and the entertainment is immense. Hill billy, mountain ballads, negro songs, revival and other "sacred" affairs, dance music—it is hard to believe that these were standard commercial records many of which sold in large numbers, mostly, we can guess, to a local clientele.

Don't ask me how Folkways gets all of these, permission-wise, but the origin of every one is given in black and white, catalogue number and label, for all to see in an interesting accompanying brochure. No hi-fi here, but, aside from missing highs, some of the earlier recording is remarkably good.

American Organ Music (Bingham, Edmundson, Haines, Sowerby, Simonds). Catharine Crozier. Sowerby, Organ Symphony in G. Crozier.

Kendall LP 2554, 2555

An organist's organist plays organists' organ music. None of this pretty-pretty Baroque stuff here—this is the sort that (every so often) swells out to blow the roof off; it has that grand and heady blur to its sound that thrills some people and bores others to death.

Frankly, I'm mostly in the latter category here.

Nor can I promise you more than the average number of bottom low notes. (After all, an organ composer has a lot of other notes to attend to.) Still—this is grand organ recording of its sort and it should please many owners of large speaker set-ups.

Voices of Haiti. Recorded by Maya Deren. Elektra EKLP-5

The fact that the convincing sounds on this record were made on a wire recorder, powered by a car battery, is only one aspect of its interest. Among all the flood of "ethnic" and otherwise exotic recorded material this stands out as unusually genuine. One can gather that, not only from the obvious intensity of the wild religious ritual dance and music, but from the excellent notes by Maya Deren who made the recordings; she points out that this is no show for foreigners or for employers, or for the performers' amusement and relaxation—it is the serious business of working, according to prescribed ritual, in the presence of divinity itself, in order to deserve blessing from the only powers that are conceived

as more potent than any man or group of men. A serious, life-and-death business this, and it sounds it. The recording is really extraordinary, its only major defect being a hum in the bass, possibly exaggerated by equalization in the copying process. Odd items such as a police whistle, adopted as part of the ritual, and a stepped-on chicken add to the bizarre quality.

MORE ODDIANA

Music and Bird Songs. James H. Fassett, commentator. (CBS intermission feature). Comstock Publ. Co. (Cornell Univ.) Ithaca, N. Y.

A ten-inch LP (Cornell's first, after much urging) of the tricks with recorded bird songs that Mr. Fassett produced last spring during an intermission of the New York Philharmonic concert. The birdies are slowed to half, quarter, and eighth speed with some very strange and interesting results. Seems they often sing two or three things at once, a chamber music ensemble within the avian voice box! Good quality throughout.

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PHONOGRAPH PICKUP *(from page 20)*

pickup to this driving characteristic is also sketched in the figure. The actual response curves were measured with the pickup output terminals connected to an effectively infinite electrical impedance.

The measured impedances for a number of pickups indicate that most pickup-pickup arm combinations have one simple, series mechanical resonance and from one to several series-parallel resonances in the range between 30 and 10,000 cps. The data of Fig. 3 illustrate this finding. The series resonance occurs near 1800 cps where the reactance curve passes through zero. Two series-parallel resonances are observed with pickup-arm "A"—one near 55 and the other near 105 cps. A third resonance which occurs near 12,000 cps is being approached at 10,000 cps, the upper frequency limit of the measurements. When the impedance and response characteristics are compared it becomes apparent that a complete correspondence between the two does not exist. That is, irregularities in the response characteristic are not necessarily accompanied by comparable variations in the mechanical impedance at the stylus, and vice versa.

Mechanical Circuit

A qualitative explanation of the various observed features of the impedance characteristic of Fig. 3 can be given in terms of the mechanical system of the pickup and pickup arm. The construction typical of many crystal pickups is illustrated at the top of Fig. 4, and the principal mechanical elements are labeled. Lateral motion of the stylus as produced by the modulation of a record groove is converted into a combination of lateral bending of elements within the pickup and pickup arm (not shown) and rotational twisting about a horizontal axis through the crystal. Thus, the mechanical system is one having both torsional and lateral degrees of freedom and it may be represented by the block diagram at the center of Fig. 4. The input terminals represent the stylus tip of the pickup. M_{sx} is the mass of the stylus and C_{sx} is the lateral compliance of the stylus arm. The blocks, Z_x and Z_θ , represent, respectively, the mechanical impedances due to lateral bending and rotational twisting of the mechanical elements of the pickup and pickup arm. These impedances are referred to the point of application of the driving force, namely, the stylus tip.

Since the axis about which the crystal twists does not pass through the stylus tip, the torque causing the twisting is the product of the lateral force at the stylus tip and the perpendicular distance between the stylus tip and the axis of twisting. The conversion from lateral to rotational motion can be represented by an ideal mechanical transformer, and the effective lateral impedance due to rota-

tional impedance referred to the stylus can be found in a manner analogous to finding the secondary load impedance reflected into the primary circuit of an ideal electrical transformer. The impedance, Z_θ , at the stylus is this reflected rotational mechanical impedance.

When the individual mechanical elements composing Z_x and Z_θ are considered, the more complete mechanical circuit shown at the bottom of Fig. 4 results. The mass, compliance, and mechanical resistance elements are represented by the symbols of their electrical analogs, namely, inductance, capacitance, and electrical resistance. Mechanical force is taken to be analogous to electrical voltage and velocity is analogous to electrical current. We shall suppose that a constant-velocity generator drives the system. This is equivalent to assuming that the device which drives the stylus has an infinite mechanical impedance. While this assumption is not always justified when a record groove drives the stylus, it is probably valid when impedance measurements are made with the stylus seated in a groove on a steel vibrator.

The circuit of Fig. 4 can, of course, be made as complicated as one pleases by allowing for higher-order modes of vibration (breakup) of the mechanical elements and by using distributed rather than lumped elements. However, the circuit as shown is capable of explaining the salient features of the impedance characteristic given in Fig. 3.

The series-parallel resonances exhibited in the neighborhood of 55 and 105 cps by the pickup impedance characteristic in Fig. 3 may be produced by combinations of elements in the configuration shown in Fig. 5. The impedance calculated for this circuit is plotted above the schematic. When an estimate is made of the relative magnitudes of the elements in the pickup circuit of Fig. 4 it is seen that at low frequencies the circuit can be simplified to two series-parallel combinations, each of the type shown in Fig. 5. One of these is M_{tx} in series with C_{rx} and R_{rx} , shunted by C_{sx} . This combination gives the resonance at 55 cps. This resonance is often referred to as the lateral pickup-arm resonance. The other series-parallel combination is M_{rx} in series with $C_{r\theta}$ and $R_{r\theta}$, shunted by C_{sx} . This gives the torsional pickup-arm resonance at 105 cps.

An explanation must be given for including the compliance, C_{sx} , in series with the pickup-arm mass, M_{tx} . While we have been referring repeatedly to lateral motion of the pickup stylus, the motion is actually rotational, with the axis of rotation for low frequencies being vertical and passing through the pickup-arm vertical pivot. However, the distance from the stylus to the pickup-arm vertical pivot is so great in comparison with the amplitude of the stylus

vibration that the arc through which the stylus moves is practically a straight line, and the vibratory motion may properly be described as lateral. Since the arm must be able to rotate freely about its vertical pivot as the pickup follows the spiralling groove across the record, a d.c. path must be provided from the input terminals through M_x , M_{ex} and M_{rx} in Fig. 4. This means that C_{rx} must be an infinite compliance—that is, a direct connection from the lower end of M_{rx} to the input terminal.

When sufficiently large forces are applied to the stylus, C_{rx} is, indeed, infinite. But when relatively small forces are applied to the stylus, the pickup-arm vertical pivot does not rotate. There is sufficient static friction and binding in the pivot bearing to make it behave like a rigid member for forces too small to overcome the friction. Hence, for the forces due to groove modulation or due to actuation of the stylus by a vibrator, C_{rx} is large but is not infinite. Consequently, instead of a mechanical reactance characteristic approaching zero with decreasing low frequency as would occur with a perfect pivot bearing, a reactance value of minus infinity is approached. This is demonstrated in Fig. 3.

Looking once more at the reactance characteristic in Fig. 3 we see that as the frequency increases above the lateral and torsional resonances near 55 and 105 cps, the reactance remains negative up to about 1800 cps. Near this frequency the reactance passes through zero and becomes positive. In the frequency range near 1800 cps the mechanical system has a resonance due to a mass and a compliance in series. The principal elements involved in this case are the stylus mass, M_x , and the stylus-arm compliance, C_x .

The resonance approached at 12,000 cps in Fig. 3 is known to be due to break-up of the stylus arm. At these high frequencies the distributed mass of the stylus arm must be taken into account, and the representation of the stylus arm by a single element, C_x , in Fig. 5 is no longer adequate.

As Fig. 3 shows, the resistive component of the mechanical impedance of the pickup is negligible except near parallel resonances. At parallel resonances very large circulating currents (velocities) flow in the parallel circuits, and the effect of any small resistance is greatly magnified.

In the type of crystal pickup sketched in Fig. 4 the voltage output is generated by twisting the crystal. In terms of the schematic, the output voltage is proportional to the strain in C_{ex} . It is evident that this circuit element is not closely coupled to the input terminals at all frequencies. Consequently it is not surprising that a complete correspondence does not exist between the pickup response and the impedance characteristics.

Recapitulation

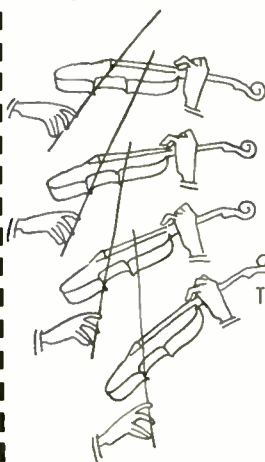
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effective lateral mechanical impedance at the stylus of a phonograph pickup and over a relatively wide range of frequencies. The impedance measurements made by this means are generally accurate within ± 15 per cent. The measured impedance and response characteristics of the crystal pickup chosen for purposes of illustration are seen to be qualitatively consistent with the mechanical circuit of the pickup. The mechanical circuit of this twister type of crystal pickup is more complicated than almost any other type in current use. Many modern pickups are, in fact, little more than a cantilever beam in simple flexure, and the analogous circuit in such cases is extremely simple for most of the audio range.

In Part II of this presentation we shall show the measured lateral impedances for a number of typical phonograph pickups.

Equipment Report

(from page 42)

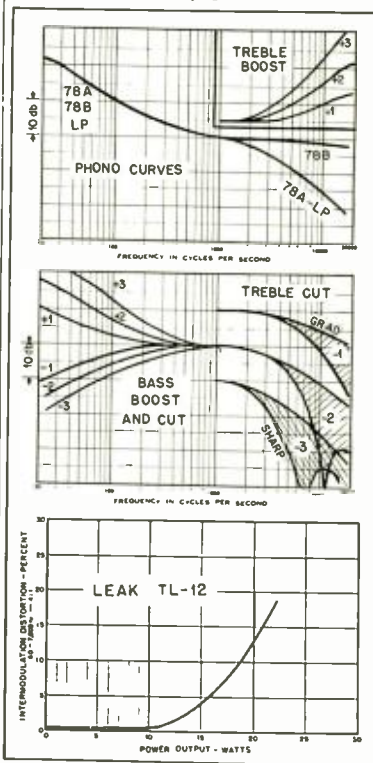


Fig. 3. Measured response and performance curves for the Leak amplifier.

or distortion was observed when the two cathodes were connected together by a clip lead, which may appear strange to students of typical push-pull amplifier stages.

The power amplifier is well built, employing paper capacitors for plate-supply filtering and assembled in a manner which provides easy access to all capacitors and resistors for replacement. Wiring is cabled wherever possible, the entire construction is a model of neat construction. The over-all quality of the amplifier is attested by its use in many professional applications in its native country.

RADIO INVENTIONS

(from page 36)

domain for hundreds of years and the extension of its use has been through the discovery of new mathematical principles to which it has so readily lent itself. The development however, has been in the science of mathematics rather than the mechanics of the rule. Certainly no one has or can claim a patent on well known mathematical tables.

"It may be that new tables will be developed concerning the theory of relativity, a quantum theory of mechanics or perhaps concerning fissionable material or atomic energy, and if mathematics succeed in reducing these to different formulae they will probably be put on scales to be used with slide rules.

"It has been held many times that for a patent to be valid a patentee must have invented or discovered a new and useful art, machine, manufacture, or composition of matter or a new and useful improvement thereof, not known or used by others prior thereto; that there must be a novelty and utility and originality. The very act of invention must be an application in a new and useful way of something not previously known."

A decision of the Federal Circuit Court of Appeals summarized these essentials for patenting an invention.

"The statute defines what inventions are patentable and novelty is only one of the ultimate facts required. If one constructs something new he has invented it but that does not mean that it is patentable. Frequently an invention is the result of mere mechanical skill or it may be anticipated by a prior art although not precisely the same, or it may not be useful.

"In each of such events the device or product is not a patentable invention but it is an invention nevertheless. This is not merely a fanciful discrimination with respect to the meaning of words, for the statute authorizing patents is clearly based upon it.

"Generally speaking with reference to the subject matter permitted to be patented there are four ultimate facts which must exist before an invention is patentable—authorship, ownership, novelty, not as a result of mere mechanical skill, and utility. If they exist concurrently the disclosure is patentable; if one is lacking it is not patentable."

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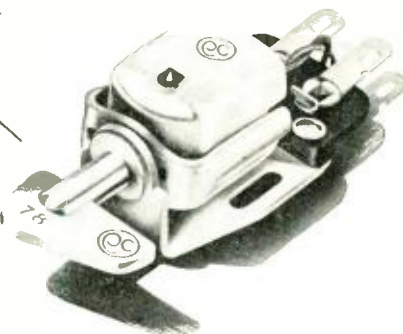
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AUDIOLOGY

(from page 14)

transformer hum pickup less than pickup in the connecting leads.

9. Particularly if mechanical considerations dictate the use of a steel chassis, mount the power transformer with the plane of laminations perpendicular to the chassis rather than parallel thereto. In general, the higher the a.c. flux density at which the power transformer operates, the stronger will be the magnetic field surrounding it, and the more complex the waveform of voltage induced in susceptible portions of the circuit. Some reduction of external field may be had by suitably wrapping the power transformer core and coil with a low-resistance, shorting band. Often over-all power transformer performance, including reduction of surrounding magnetic field, may be improved by stacking the laminations in alternate groups of two, instead of 100 per cent interleaved. Enclosing the entire power transformer in a magnetic shield of high-permeability nickel alloy is sometimes done, but is costly due to the large amount of material required. Also, the field close to the power transformer core is usually strong enough to saturate a close fitting shield and render it relatively ineffective. Then two shields with non-magnetic separator may be used, the inner shield to reduce the field to intensity small enough that the outer shield can be effective.

10. Mount power supply and amplifier circuits on separate chassis. An annoyance sometimes encountered in amplifiers, especially those using choke-input power-supply filters, is in the form of short-duration spikes at power line frequency. A common cause of this interference is coupling of the very large rectified sinusoid at the rectifier filament, via stray capacitance, into low-level portions of the amplifier circuit. Sudden irregularity in the rectified waveform at the instant current shifts from one rectifier plate to the other, is differentiated by stray capacitance connection to form complex interference with a narrow spike predominating. Interference due to this cause sounds in the loudspeaker like the buzz associated with nearby fluorescent lamps. It tends to be worse with high leakage inductance in the plate transformer, and with filter-choke inductance less than the so-called critical value for prevailing load conditions. Simply operating amplifier heaters from a separate transformer may not be very helpful in this regard, due to coupling with the rectifier transformer via the common primary connection.

Means individually or collectively effective in reducing this interference to negligibility are: a small capacitance (such as 0.05 μ f) from rectifier filament to ground; grounded electrostatic shield between rectifier filament and amplifier heater windings, or preferably a grounded shield separating high-voltage and rectifier filament windings from all other windings; shielding rectifier filament leads and the input lead to the filter choke.

Perhaps the best arrangement with single power transformer is an electrostatic shield separating the amplifier heater winding from all other windings, and a second shield separating the primary winding from all other windings. The latter shield reduces interference either to, or due to other equipment.

In a related way, capacitor-input filters

are sometimes troublesome, though to lesser extent. In this type of filter, ripple at the input is customarily only a few per cent of the d.c. voltage. But the rectifiers are biased by the potential to which the input filter capacitor is charged, with the result that any one rectifier conducts only during the portion of the input cycle that this bias potential is exceeded by the alternating voltage on the rectifier anode. Thus successive current pulses in the transformer high-voltage winding are the tops of sine waves. Differentiation of this current waveform by the transformer leakage inductance produces steep wavefronts of voltage riding on the sine wave at the rectifier plate. Differentiated a second time by stray capacitance coupling, the interference becomes short-duration spikes in the signal circuits, and may result in audible buzz in the loudspeaker.

NEW TYPE TAPE REEL

Designed to minimize errors in program timing, a new 7-in. plastic reel recently announced by Minnesota Mining and Manufacturing Company also permits more rapid threading of tape. Two threading slots are provided on each side of the reel, one being a new "V" slot that reduces threading time by nearly one third. The reel contains 45 per cent more plastic and features wider and heavier spokes. The hub diameter is $2\frac{1}{4}$ in., providing a better ratio between maximum and minimum diameters than the older reel types, yet capable of holding a 1200-foot-plus length of standard-thickness tape, which was not possible



with the 2.75-in. hub without danger of spilling tape. The latter hub was designed for tape of slightly thinner base, which has occasionally been reported as causing inaccurate program timing with certain recorders.

More even winding of the tape on the reel is provided by reduced inside width of the reel and use of tapered flanges, which also serve to lower the possibility of nicked edges. Another improvement is smooth-surfaced spokes which provide greater labeling surface.

NEELY DROPS AUDIO; KOESSLER TAKES OVER

Retirement of Neely Enterprises, Los Angeles factory representatives, from the sound equipment industry after 20 years of specialization, was announced last month by Norman B. Neely, president. In the future, the Neely organization will devote its facilities to the sale of electronic instrumentation and industrial control equipment.

Frank B. Koessler, who has been in complete charge of Neely's sound equipment division for a number of years, concurrently announced the formation of Koessler Sales Company which, as of July 1, will become representative of all sound equipment companies formerly serviced by the Neely organization.

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Model PA-30 Driver Unit
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Impedance: 16/165/250/500
1000/2000 ohms
Power Tap: 170V
30/20/10/5/2.5 Watts



Model SA-30 Driver Unit
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Response: 90-10,000 CPS
Impedance: 16/65/165/250
500/1000/2000 ohms
Power Tap: 170V
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PUSH-PULL

(from page 23)

odd-order components. (Remember that the fundamental is an odd-order component, too.)

Figure 24 is a graphical representation of the frequency components which comprise our complex wave. The fundamental is labelled f and its third harmonic $3f$. The waveform which results from the vectorial addition of the two is the dotted line labelled "resultant."

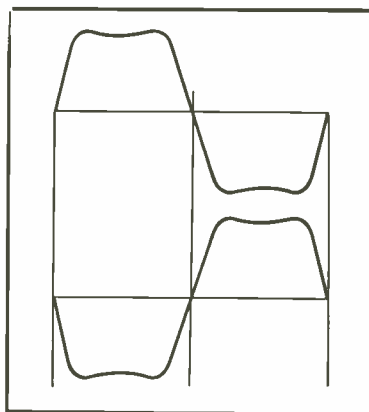


Fig. 25. Simultaneous presentation of the waveforms on the two plates of a push-pull stage. (A) is that on the upper plate, and (B) is that on the lower plate.

If an electronic switch is now used to permit simultaneous inspection of the output wave-forms of both halves of the push-pull stage on a scope, we will see the two complex waveforms of Fig. 25. Graphically analyzing them into their component frequencies, we get the picture of Fig. 26. (In this diagram, too, each fundamental is labelled f and its third harmonic $3f$.) The dotted lines represent the respective resultants.

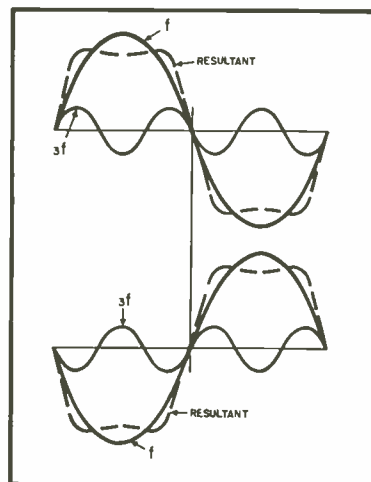


Fig. 26. Waveforms of Fig. 25 analyzed into their components. Fundamentals are 180 deg. out of phase, as would be expected, and so are their third harmonics. Therefore, both would appear in the output of the stage.

It is plain that the fundamental components of the two complex waves representing the original input voltages are 180 deg. out of phase with each other. But so are their third harmonics.

This means that both the fundamentals and the third harmonics will produce output voltages which will be heard in the earphones. The same will apply to any odd-order components of the fundamental frequency.

As we already know, any second and other even-order harmonic components generated in the stage itself tend to be cancelled out. On the other hand, odd-order-components produced within the stage are amplified and delivered to the phones as part of the output voltage.

A subsequent article will extend the above presentation to the Class B case

and also to the case of the inductive load.

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TAPE RECORDING PERFORMANCE

(from page 27)

this point results in the mechanism running slow. The friction supplied by the take-up reel clutch should allow the tape to move at normal speed and prevent tape throwing when the machine is stopped after the rewinding operation. These adjustments can be made by using a small spring balance. With an empty standard reel on the take-up spindle, a length of string should be wound around the reel hub, the other end of the string being attached to the balance. With the spring balance held in a vertical position, as shown in the Fig. 3, start the recorder and read the pull of the mechanism in ounces. It is recommended that this tension be from 5 to 6 ounces, and this may be obtained by adjustment of the clutch at the rear of the spindle, Fig. 4, to obtain more or less friction, as required. The supply reel clutch should be similarly adjusted, except that the motor is not used, but the tension is found by placing the empty reel and string on the supply spindle and pulling the spring balance upward, observing the reading in ounces at the instant the reel begins to turn.

These tension values are in inch-ounces, which can be ascertained by multiplying the value indicated by the spring balance by the distance in inches from the center of the reel spindle to the tangency of the string where it leaves the reel hub. In the case of the standard 7-in. reel, this distance is very close to one inch, so that the absolute indication on the spring balance can be taken as being correct. When using the new larger hub reels, the tension in inch-ounces can be obtained by multiplying the pull in ounces as indicated on the spring balance by a factor of 1.375, since the radius of the new hub is approximately $1\frac{3}{8}$ in.

The spring attached to the rubber pressure roller that holds the tape in contact with the capstan must also supply the correct tension. Too little pull from this spring results in slippage and may even cause complete stoppage of tape movement. Extreme care must be exercised in oiling the mechanism. The

smallest amount of oil on the rubber idler wheels produces serious slippage, with resulting wows and timing discrepancies. Both the pressure roller and idler wheels should be kept clean by wiping with a cloth just dampened with carbon tetrachloride.

Sticky tapes have contributed to speeds variations and, in extremely humid climates, have actually stopped the mechanism. Most presently available tapes are being produced with adequate lubricant in the coating which is resistant to high humidity and temperature. The newer tapes eliminate the squeal often heard as the tape moves over the heads.

The new 7-in. professional reel is another step toward eliminating speed variations and timing discrepancies. This new reel has a hub diameter of $2\frac{3}{4}$ in. which approaches the NARTB standardized $2\frac{1}{2}$ -to-1 ratio specified for the $10\frac{1}{2}$ -in. professional reel. In the normal operation of a tape recorder there is less tape tension with a full tape on the supply reel than when the reel is almost empty, and tape speed is faster at the beginning, becoming slower as the end of the tape is reached. The larger hub reduces the differences in tape tension and speed between the beginning and end of the reel, resulting in greater timing accuracy and reduction in pitch changes, noticeable particularly on classical musical selections when, due to the length of the composition, more than one recorder is employed.

Using the techniques outlined, the recorders have been adjusted to a timing accuracy within 5 seconds or less in 30 minutes. To hold this close timing in mechanisms without synchronization, constant surveillance of the mechanism performance is required. It has been observed that greater accuracy results when speed checks are made over longer periods than just a minute or so. It is interesting to compare the results obtained when several methods are employed in any particular test.

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Model 10C Basic Amplifier 228.

Model 10C4 Remote Control Amplifier (combines Model 10C above with Model 4B Pre-Amplifier) 331⁵⁰



Sounds incredibly lifelike, thanks to new one-octave extension of low-frequency range, and 9-position playback characteristic control matching the characteristics of all type records. Frequency range 20-20,000 cps. Pre-Amp unit in de luxe gold-finished console.

BROOK All-Triode 10 Watt Amplifier

Model 12A Basic Amplifier 118⁵⁰

Model 12A4 Remote Control Amplifier combines Model 12A above with Model 4B Pre-Amplifier



222.

A medium-priced amplifier which, except for lower power rating, equals the famous Model 10C4. Transient peak circuit permits distortion-free power peaks considerably higher than 10 watts. Frequency response from 20-20,000 cps. Pre-Amp unit in smart, gold-tone console.

NEW! BROOK Model 7 Pre-Amplifier



Has all features of Model 4B Pre-Amplifier, PLUS BUILT-IN POWER SUPPLY. May be used in combination with your present wide-range basic amplifier. Smart, gold-finished console. 119⁷⁰

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Radio Corp.**

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WO 4-3311

NEW PRODUCTS

• **Studio Turntable for Fine-Groove Records.** Disc jockeys will welcome this new unit recently announced by RCA, because it has been designed especially for their convenience. Designated the Type BQ-1A fine-groove turntable for 45 and 33 1/3-



r.p.m. records, it has several novel features, including a spindle hub which changes diameter simultaneously with operation of the speed control knob, and a quick-starting mechanism which attains full speed in 1/4 revolution. Operation of the on-off mercury switch also disengages the driving idlers when not in use. Lightweight 12-in. tone arm accommodates plug-in heads and will play records with warp up to 1/8 in. A 4-position filter is included for record compensation. RCA Victor Division, Radio Corporation of America, Camden, N. J.

• **Binaural-Monaural Speaker System.** Equally well-suited for use with single- or two-channel audio systems, the new Bzok B-204 speaker includes two woofers and two dual tweeters, all of which are mounted in a heavily-constructed enclosure of unique design. Although the woofers are mounted in the usual fashion, the tweeters depart from the conventional



in the fact that the two sets are mounted back-to-back, each set radiating through a port in the side of the cabinet on which it is mounted. Hinged deflectors at each side, which fold flat when not in use, are used to provide improved high frequency dispersion when the system is used monaurally, and to enhance dimensional effect when binaural sound is being reproduced. The two sound sources are separated by more than three feet. Manufacturer's published specifications state that the frequency range of the B-204 is 35 to 20,000 cps, power rating is 25 watts per channel, and impedances are 8 ohms when used with binaural equipment and 4 ohms when all drivers are paralleled for connection to a single-channel system. A phase-reversing switch is provided, and the crossover network is included in the cabinet. Further information may be obtained by writing R. T. Bzok Company, 114 Manhattan St., Stamford, Conn.

• **Tape Carrying Case.** Tape recording enthusiasts will welcome the new vinyl plastic carrying case which has been developed by Reeves Soundcraft Corporation, 10 E. 52nd St., New York 22, N. Y.,



for transporting 5- and 7-in. rolls of magnetic recording tape. Developed primarily for use with the Soundcraft Tape-Chest, the case is equally desirable for carrying spools of tape in separate containers.

• **Tiny High-Fidelity Transformers.** Although sealed and potted in aluminum cases, only 7/8 in. square, Stancor's new Tinytrans have exceptional frequency



range of 30-15,000 cps within ± 1 db. Total height, including terminals, is 1 1/4 in. and maximum level is zero db. Weight is only 1.3 ounces. The case is equipped with two 2-56 threaded inserts for easy chassis mounting. Laminations are of nickel steel. Standard Transformer Corporation, 3580 Elston Ave., Chicago 18, Ill.

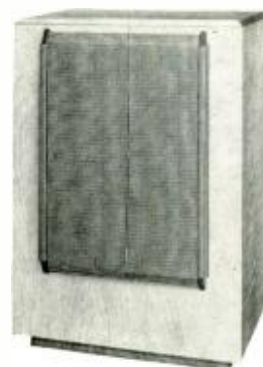
• **Turnover-Type Ceramic Pickup.** Unique construction of the new Titone cartridge is emphasized in the fact that the stylus alone is rotated to accommodate various types of recordings. Using a high-compliance highly-sensitive ceramic element,



the unit has an output approaching one volt and does not require pre-amplification or equalization. It is unaffected by moisture or temperature. Tracking force is 9 grams and recommended load is 1

to 10 megohms. Mounts in place of any standard cartridge using 1/2-in. mounting centers. Manufactured by Sonotone Corporation, Elmsford, N. Y.

• **Speaker Enclosures.** While designed primarily for housing Tannoy full-range dual-concentric loudspeakers, two new wall- and corner-type Tannoy bass-reflex enclosures will provide optimum acoustic loading and balance for many other makes



of 12- and 15-in. speakers as well. Constructional features of the enclosures include the use of 3/4-in. lumber with all joints close batted, screwed and glued, and complete internal lining of sound absorbent material. The corner enclosure is known as the Parliament, while the wall model is named the Westminster. Manufactured by Beam Instruments Corporation, 350 Fifth Ave., New York 1, N. Y.

• **Portable Tape Recorder.** Exceptional audio quality is attained along with small size and portability in the Magnematic, a new 110-volt a.c. tape recorder recently placed in full-scale production by Amplifier Corp. of America, 398 Broadway, New York 13, N. Y. Although weight of the Magnematic is only 19 lbs., it contains



many features normally associated with standard professional tape recorders. Frequency response is 50-15,000 cps at 7 1/2 in./sec. tape speed. Completely operated by push-button control, the unit features a solenoid-operated clutch-controlled capstan drive to start and stop tape travel in 1/20 sec. Incorporates relay-operated modified Geneva movement to control 60-in./sec. rewind and fast forward. Has 5-in. reel capacity. Headphone monitoring. A built-in preamplifier provides for low-level low-impedance microphone input. Dimensions are 8 1/2 x 11 x 9 in. Meeting primary NARTB standards, the Magnematic is designed specifically to produce tapes in the field which equal in quality those usually recorded on studio equipment.

• **Three-Speed Manual Record Player.** Excellent speed stability and virtual freedom from induced hum when used with magnetic cartridges are among the features of the new Garrard single-play turntable. Designated Model T, the new unit embodies a number of performance standards which have heretofore been confined to the field of expensive profes-



sional equipment. A small knurled knob located conveniently at the rear of the tone arm permits accurate adjustment of stylus pressure. The tone arm shell fits all popular makes of pickups and is equipped with a professional-type finger lift, also a clip lock to hold the arm in place when not in use. Another principal feature is automatic start and stop which operates with records of all sizes and speeds. Dual-voltage (100/120 and 200/250 volts, 60 cycles) motor is of the 4-pole type and the unit employs a heavily weighted turntable. Garrard Sales Corporation, 164 Duane St., New York 13, N. Y.

• **Super Tweeter.** The new Electro-Voice T-35 driver-horn assembly is a complete high-frequency reproducer which can be added economically to any existing speaker system. Easily installed in a few minutes, the T-35 has a frequency range extending



from 5500 cps to the limit of audibility when used with the E-V Type X-36-1 crossover network. Horizontal dispersion is 180 deg. A companion accessory is the AT-37 level control for adjusting output level to individual tastes. The T-35 may be used with any system up to 10-watt rating. Impedance is 16 ohms. Horn dimensions are 4 1/2 in. long by 1 3/4 in. high. Over-all depth is 3 1/2 in. and weight is 2 lbs. Complete information is available from Electro-Voice, Inc., Buchanan, Mich.

• **Heavy-Duty Rotary Switches.** A unique detent mechanism which provides non-shorting action is featured in two new single-deck single-pole rotary switches recently announced by Shallerose Manufacturing Company, Collingdale, Pa. Available



in 60- and 36-position models, the switches are designed for complicated range or circuit switching of heavy-duty test equipment. In action the rotor arm is actually

lifted as it moves from one contact to another, thus providing non-shorting operation in the smallest possible space. Large silver contacts provide average contact resistance of less than 0.006 ohm. Current-carrying capacity of the 60- and 36-position types is 30 and 40 amps, respectively, while respective breakdown voltages are 1500 and 2500. Further details will be supplied upon letterhead request to the manufacturer.

NEW LITERATURE

• **Standard Transformer Corp.,** 3580 Elston Ave., Chicago 18, Ill., is now publishing a transformer replacement guide for tape and wire recorders—listing 63 models for 22 companies which manufacture units for home use. Manufacturer and model number, manufacturer's part number, and corresponding Stancor number are listed for all models included in the guide, the first of its kind available to distributors and service engineers.

• **Sorensen & Co., Inc.,** 375 Fairfield Ave., Stamford, Conn., includes full information on the company's extensive line of electronic a. c. line regulators in Catalog No. 353, a handsomely-prepared booklet which leaves little to be desired in both attractiveness and effectiveness. Also contained in the catalog is an abundance of information on the selection and use of regulators in general. May be obtained by writing General Sales Department.

• **Minnesota Mining and Manufacturing Co.,** 900 Paquetter St., St. Paul 6, Minn., discusses the properties for four basic types of magnetic coatings in "Sound Talk" technical bulletin No. 22. Also described are 14 different magnetic tape constructions. Four graphs are included, which show typical hysteresis loops and magnetization curves for the oxides discussed. Available upon request.

• **Audak Company,** 500 Fifth Ave., New York 36, N. Y., is distributing a new edition of "Electronic Phono Facts" by Maximilian Weil. Made up of 20 pages, the new edition is twice the size of the former issue, of which approximately 100,000 copies have been distributed. Contained are answers to more than 100 commonly asked questions on hi-fi music systems. Available free from Audak dealers, or by writing direct to the address shown above.

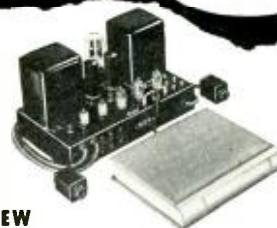
• **D. W. Onan & Sons, Inc.,** Minneapolis 14, Minn., is issuing a 2-color folder which shows examples of portable and mobile electric plants providing standby power for communication systems. Also described and illustrated are units which provide primary power for mobile TV studios. Requests for copy should specify Form A-204.

• **Insulation Manufacturers Corporation,** 565 W. Washington Blvd., Chicago 6, Ill., includes a great deal of helpful information on the features and uses of fibre and plastic for electrical insulation in two new catalogs which are available free of charge. An 8-page booklet is devoted to fiber-reinforced plastics, while Phenolite laminated plastics, National vulcanized fibre, and Peerless fishpaper are covered in a 32-page companion publication.

• **Methode Manufacturing Corporation,** 2021 W. Churchill St., Chicago 47, Ill., is publishing a new handbook on printed circuits, titled "Utilization of Prefabricated Wiring," which provides detailed engineering data to those interested in applying printed-circuit techniques to electronic equipment. The 32-page booklet deals with present applications of printed circuitry, layout of schematics, component selection, Underwriters' requirements, service techniques, etc. Available to those requesting on business letterheads.

• **Cornell-Dubilier Electric Corp.,** South Plainfield, N. J., has just completed Bulletin NB-148, a 12-page catalog of descriptions, illustrations, and technical data covering the company's wide line of Quietone interference filters. Included in the catalog are Quietones for virtually every type of electrical and electronic equipment. In addition to electrical characteristics, there are shown outline drawings, circuit diagrams, and photographs. Available without cost from nearest C-D distributor.

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93-805. Net.....\$232.26



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former. Uses the famous McIntosh-patented output transformer. Exceedingly wide response— ± 1 db, 10-100,000 cps at 15 watts; ± 0.1 db, 20-30,000 cps at 30 watts. Only 1/2 volt for full output. Output Impedance: 4, 8, 16 and 600 ohms.

93-895. Net.....\$139.50



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96-555	1/4x1200'	Std. 7" (2 3/4" hub)	\$4.67	\$4.30
96-558	1/4x1200'	Prod. 7" (2 3/4" hub)	4.34	3.90
96-556	1/4x2400'	NARTB hub	8.67	7.80
96-557	1/4x2400'	NARTB reel	10.57	9.51

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WRITE FOR CATALOG

PRECISION ELECTRONICS, Inc.
910 King Avenue, Franklin Park, Ill.

LONDON & PARIS

(from page 40)

circular staircase in a concrete tower so as to provide realism of sound effects when used in dramatic works laid in castles or chateaux.

Echo chambers at BBC were relatively simple, but differ from U. S. practice in that most of the studios had an echo chamber permanently assigned to them, and located adjacent so set-up changes could be made readily. New switching facilities are being provided so that multiarm stepping switches will transfer all of the circuits of a given studio at the same time—simply by actuating one control button.

Audio—and this certainly means the important part of radio broadcasting, for it is the audio portion of the signal that is of interest to the listener—is no less important in England or France than it is here. Were it possible for engineers to be exchanged for periods of two or three months between the broadcasting companies and between manufacturers, it is certain that improvements would result on both sides of the Atlantic. For our part, we certainly would have liked to spend much more time in both London and Paris, and to have been able to extend the trip to Rome, Vienna, Switzerland, Germany, Norway, Sweden, and Denmark. Perhaps next year—



Employment Register

POSITIONS OPEN and AVAILABLE PERSONNEL may be listed here at no charge to industry or to members of the Society. For insertion in this column, brief announcements should be in the hands of the Secretary, Audio Engineering Society, P. O. Box 12, Old Chelsea Station, N. Y. 11, N. Y., before the fifth of the month preceding the date of issue.

★ Positions Open • Positions Wanted

★ **ENGINEER**, for acoustic and audio research laboratory of progressive manufacturer located in pleasant New York suburban area. Must have good background in loudspeakers, microphones, transducers, and physics of moving systems. Challenging opportunity and attractive salary commensurate with experience and past achievements Box 601, AUDIO ENGINEERING.

• **COLLEGE SENIOR**, specializing in musical instrumentation, well grounded in physics, with experience in many phases of the record pressing industry, the recording process, and the construction and operation of audio and video equipment desires summer employment from mid-June through mid-September, within Metropolitan New York. Emerson Boardman, 5533 Whitty Lane, Brooklyn 3, N. Y. Telephone: ULter 6-6414.

Binaural Phonograph Records

In response to many inquiries as to the availability of binaural recordings and the titles already recorded in this new medium, we are pleased to list below the entire catalog available from Cook Laboratories, 114 Manhattan St., Stamford, Conn. The recording companies responsible for the originals are indicated. Most of these recordings may also be obtained from local audio jobbers.

Inside Vienna—A quartet of two violins, accordion, and the zither-like contraguitar with close microphone technique.

Cook 1026-BN

Fiesta Flamenca—Carlos Montoya and four dancers, with castanets, heel and toe, clapping, etc. Transients distinctly dominant, motion of dancers evident.

Cook 1027-BN

Paganini Variation—Piano studies, Frank Glazer. Single piano.

Polymusic 1036-BN

Two Famous European Pianos—Ballade for Flute with Orchestra. Hindemith and Frank Martin, coupled for variety in modern music—instrumental and orchestral on the same disc. The Hindemith employs two 13-foot matched concert grands.

Cook 1037-BN

The Pipe Organ in the Mosque, Parts I and II. Michael Cheshire. Theatre acoustics are recreated in the listening environment. 32-cps pedal notes.

Cook 1050-BN, 1051-BN

Percussion and Pedal. Reginald Foort, BBC organist. Reveals the entire instrumentation of the theatre organ, including bells

and all the percussives.

Cook 1052-BN

Vienna String Symphony (Collegium Musicum Wien). Kleine Symphony, Opus 44, Hans Pfitzner, cond. 35-piece orchestra in Vienna Concert Hall acoustics.

Audio Collector 1061-BN

Hufstader Singers—performing madrigals and modern song in the Engineering Auditorium acoustics.

Cook 1092-BN

Voices from Vienna—136 massed voices sing with orchestral accompaniment.

Audio Collector 1093-BN

New Orleans Jazz—Wilbur deParis (Rampart St. Ramblers). Dixie, with sharp division between ensemble and brass, in auditorium acoustics.

Atlantic Binaural 1208-BN

Masterpieces from the Theatre, Orchestral Society of Boston. Bizet: Introduction to Act I, Carmen; Rossini: Overture to La Gazza Ladra; Mendelssohn: Scherzo from Midsummer Night's Dream; von Weber: Overture to Euryanthe.

Cook 2064-BN

Mozart, Symphony No. 40 in G Minor. Orchestral Society of Boston.

Cook 2065-BN

Masterpieces of the Dance, Orchestral Society of Boston. Rimsky-Korsakov: Dance of the Buffoons; Strauss: Emperor Waltz; Saint-Saens: Danse Macabre; Brahms: Hungarian Dance No. 6.

Cook 2066-BN

The last three records listed may also be obtained as normal recordings—that is, not binaural—by omitting the letters "BN" from the number.



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BOOK REVIEWS

SOUND REPRODUCTION, by G. A. Briggs. Third edition, revised and enlarged. 368 pages, 315 illustrations. Wharfedale Wireless Works, Ltd., 1953. Price \$3.50. (In U. S., British Industries Corp., 164 Duane St., New York 7, N. Y.)

G. A. Briggs has done it again, in giving us here a book that will be invaluable to everyone seeking the ultimate in sound reproduction from a home music system. And in the telling, Mr. Briggs has lost none of his inimitable style, for he is a man possessed of the gift of GAB.

Dividing into two sections, loudspeakers and recording, much of the fundamental material on reproducers has appeared in earlier editions, but the new oscillographic illustrations make this presentation more interesting and informative. Mr. Briggs goes into many of the peculiarities of enclosures, room acoustics, and the speaker mechanisms themselves. But always there is the diagram to substantiate his premise.

To this reviewer, the section on recording is less interesting, not because of the material which it contains nor its presentation, but because this is not the author's main flair. Outstandingly interesting are the photomicrographs by C. E. Watts on the relations between disc wear and stylus condition. It is significant indeed that in America, where the amount of hi-fi apparatus sold far outdistances that of the British market, that no one has ever dared attempt such a book. Every one of us is in Mr. Briggs' debt, and will be for a long time, for a careful following of his fundamentals will assure the optimum sound from a given speaker and enclosure combination.

—L. B. Keim

ELECTROPHYSIOLOGICAL TECHNIQUE, by C. J. Dickinson; vii+141 pp. London: Electronic Engineering, \$2.75.

The methods employed in the investigation of electrical phenomena accompanying biological activity are quite similar in many respects to those of the audio engineer. Indeed, the frequencies of interest to the electrophysiologist cover the range from d.c. to 10,000 cps. Because the amplitude of the signals under consideration is of the order of 50 mv, and often less, the workers in this field have become quite concerned with such factors as tube noise, thermal agitation, and stability of circuits.

Because of the low level of signal input, much emphasis is placed on the elimination of in-phase signals and for this reason differential amplifiers and methods of enhancing signal to noise ratio are shown.

The author, a graduate of Oxford University, covers such subjects as power supplies, voltage stabilization, effect of power supply impedance on low-frequency amplification, d.c. amplifiers, and low-frequency capacitance-coupled amplifiers. Also of interest are the sections concerned with long-duration-sweep time bases, time markers, and methods of recording mechanical movement and changes in pressure, volume, heat and light.

The book is a collection of accepted methodology employed by British investigators and citations are made in the text to references in both British and American journals. Workers in the audio field will find it interesting as a cross section of the "state of the art" in Great Britain and will find it especially valuable as a reference in the field of low frequency amplification.

—Cullen H. Macpherson

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Miscellaneous Radio, TV, and Electronic Parts

AMERICAN PHENOLIC—Temporarily discontinued remote control wire No. 14-316(1001), 14-316(500), 14-316(1000). Discontinued remote control wire No. 14-317; twin-lead (transmission line No. 14-318).

BARKER & WILLIAMSON—Discontinued inductor material enameled wire No. 3905, No. 3906, No. 3907.

ERY SALES—Added insulated terminal strips No. T21A at \$2.10 net; No. T22 at \$3.00 net; No. T25 at \$2.10 net; No. T26 at \$2.10 net; No. T29 at \$2.10 net.

JOHNSON CO., E. F.—Discontinued copperweld wire No. 144-348; No. 144-350; No. 144-352.

MALLORY & CO.—Added No. 2600 Microtel Control Kit at \$15.60 net. Decreased prices on vibrators No. 859 to \$2.82 net; No. W859 to \$2.94 net; No. G874 to \$2.94 net.

OAK ELECTRONICS—Added 4-way multipurpose switch at \$0.90 net.

OHMITE MFG. CO.—Added Type AB (Stock No. CCI) 2-watt molded composition potentiometer at \$4.20 net.

VARI CORP.—Added Model R-115-B Vari-Hot electric soldering iron at \$7.75 list. Discontinued Model R-115-A Vari-Hot electric soldering iron.

Recording Equipment, Speakers, Amplifiers, Needles, Tape, etc.

BOGEN CO.—Added: Model H33Y high-impedance amplifier with three-speed phonograph at \$102.15 net; Model HLC3Y low-impedance amplifier with three-speed phonograph at \$117.00 net; Model E68 corner baffle for 8" speaker at \$7.50 net; Model E12 corner baffle for 12" speaker at \$7.50 net; Model ET16 three-speed transcription player at \$74.25 net.

BROWNING LABS.—Added Model RJ-42 FM-AM tuner at \$166.50 net.

DUOTONE CO.—Added Columbia replacement needles No. 360 at \$1.75 net; No. 360(1) at \$14.00 net.

GARRARD SALES—Added Model T three-speed manual player at \$25.95 net. Discontinued Model M three-speed manual player.

MILLER CO., M. A.—Added a number of new replacement needles for American Microphone, Audak, Astatic, General Electric, Magnatone, RCA, Webster Electric.

REK-O-KUT—Discontinued Model TR-12 dual speed recording turntable. Increased prices: Model LP-743 three-speed transcription turntable to \$59.50 net; Model P-43-C three-speed record player to \$99.50 net; Model P-43-M three-speed record player to \$104.50 net; Challenger Deluxe disc recorder to \$459.95 net.

STEELMAN PHONOGRAPH & RADIO—Discontinued: Model 3114 three-speed portable phonograph; Model 3ET2 transcription player; Model 3K1 three-speed electric portable phonograph; Model 3RP2 radio-phonograph.

WEBSTER ELECTRIC—Increased prices on public address amplifiers Model 81-15 to \$74.25 net; Model 82-25 to \$89.25 net.

Test Equipment

JACKSON ELECTRICAL INSTRUMENT—Discontinued: Model 618-C dynamic tube tester with counter base. Increased prices: Model 648-B bench type steel case dynamic tube tester to \$104.50 net; Model CB48 counter-base for dynamic tube tester to \$8.70 net; Model 648-P portable tester in wooden case to \$109.50 net.

SIMPSON ELECTRIC—Discontinued: Model 266 vacuum tube voltmeter. Increased prices: Model 303 vacuum-tube volt-ohmmeter to \$68.00 net.

ADDITIONAL CLASSIFIED

FOR SALE: McIntosh 50W2 amplifier, \$190; AE2A preamplifier and equalizer for McIntosh \$45; Leeds & Northrup decade resistance box, 0 to 999.9 ohms in 1/10-ohm steps, \$24; Pilot AF-821A FM-AM tuner, \$70; Klipschorn loudspeaker, \$200; Grummes 10-watt basic amplifier, \$24; Henthkit A-P generator, sine and square wave, 20 to 20,000 cps, very well constructed, \$21. Write for full details; Jac Holzmann, 189 W. 10th St., New York 14, N. Y. Phone OR 5-7137.

CLASSIFIED

Rates: 30c per word per insertion for noncommercial advertisements; 25c per word for commercial advertisements. Rates are net, and no discounts will be allowed. Copy must be accompanied by remittance in full, and must reach the New York office by the first of the month preceding the date of issue.

THE AUDIO EXCHANGE, INC. buys and sells quality high-fidelity sound systems and components. Guaranteed used and new equipment. Catalogue, Dept. AE, 159-19 Hillside Ave., Jamaica 32, N. Y. Telephone OL 8-0465.

Special Package Purchase: Ampex portable recorder, 400A series, 50-watt McIntosh amplifier, Electro-Voice 650 mike with stand, two 15-in. Lansing speakers, Permoflux headphones, all for \$1200. Mr. J. Ross, NY 7-5397 between 9:30 and 5:30.

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Send resume of qualifications and experience to Box C5-1, **AUDIO ENGINEERING**, P. O. Box 629, Mineola, N. Y.

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Highest quality discs cut from your tape or record, all sizes, all speeds. Price, 10-in. LP records, \$2.25. Also monitoring of the air and recording on location. Unifac, Inc., 80-08 135th St., Kew Gardens, N. Y. Ligtgett 4-1035.

WANTED: Presto 6N or equal. Describe condition, give best price. Chief Engineer, WHOT, South Bend, Indiana.

SAVE YOURSELF plenty on all new high fidelity equipment. Write for details, E. F. Guild, 45-4 Grace St., New York 14, N. Y.

FOR SALE: Ampex 400 dual-track tape recorder, certificated by distributor, \$750; Electro-Voice 635 microphone and accessories, \$20; six 10-in. NAB reels Scotch 111A tape, two empty reels, \$35; University 4410 crossover, 600-cps, \$10. W. D. Little, 5844 Ralston Dr., Indianapolis 20, Ind.

WANTED: Complete hi-fi outfit—tuner, amplifier, changer, etc. Prefer Craftsman or equal. George Wentz, Box 26, San Marcos, Texas.

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FOR SALE: Never used, McIntosh 2A2 with C-104, \$185; Browning RV-31, \$90. Used one month—Altec 601A, \$78; R-J enclosure F-12-M, \$39; Wm. Dougherty, 3739 N. Percy St., Philadelphia 10, Pa.

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Industry Notes...

Combined operations of **Triad Transformer Manufacturing Co.** and **Tetrad Company, Inc.**, both of Venice, Calif., have been merged under corporate name of **Tetrad Transformer Corporation**—officers are L. W. Howard, president; G. D. Perry, executive vice-president; Thomas E. Walker, vice-president; Aliah Vahlgren, secretary-treasurer; George Clark, assistant to the president; Ernest Clover, manager of jobber sales; and Charles Shaw, director of purchases... Fourth store in **Arrow Electronics** chain was opened May 1 at Hempstead, N. Y.—will be managed by Frank Gallagher, 25-year veteran in the electronics field.

March 13 marked start of production in **International Resistance Company's** new Asheville, N. C. plant—facilities will be under management of H. J. McCauley, formerly an official in **IRC's** home plant in Philadelphia... **G & H Wood Products, Inc.**, Brooklyn, N. Y., is newest manufacturing licensee of **Klipsch & Associates, Hope, Ark.**—speaker enclosures will be advertised and promoted as the **Klipsch Rebel IV** by Cabinart, **G & H's** hi-fi trade name... New midwestern representative for **Brook Electronics, Inc.**, Elizabeth, N. J., is **Ray R. Huttmacher Associates, Inc.**, Chicago.

The Turner Company, Cedar Rapids, Iowa, and **Pickering & Company**, Ocean-side, N. Y., both entertained visiting group of European industrialists in this country on conducted tour under auspices of **Ad. Auriema, Inc.**, New York, export representative for more than 30 U. S. electronic equipment manufacturers... **Ampex Electric Corporation** has completed arrangements with **Magna Theaters and Todd-A-O Corporation** to develop and manufacture special stereophonic sound equipment for use with new **Todd-A-O** system of wide-screen movies... **Sun Radio and Electronics Co., Inc.**, celebrated opening of new headquarters at 650 6th Ave., New York, April 17—will be known as "America's first electronic supermarket."

Industry People...

Robert L. Stephens, president, **Stephens Manufacturing Corporation**, Culver City, Calif., announces appointment of **Steve Van Roekel** as general sales manager—comes to new post from Omaha, Neb., where he owned **Midwest Sound Company**... **Dr. Burton Browne**, head of **Burton Browne Advertising**, Chicago, back from special cruise to Pearl Harbor as civilian guest of the Navy Department... **Peter L. Jensen**, president, **Jensen Industries**, honored with luncheon at Chicago's **Merchandise Mart** by **Electronic Parts & Equipment** manufacturers for contributions to the industry.

Albert F. Watters, whose first job with **RCA** was as spot welder's attendant in 1935, has been elected vice-president in charge of personnel of **RCA Victor Division**... **Bernie Cutler** is new addition to sales staff of **Adolph L. Gross Associates, Inc.**, New York Manufacturers' rep... **M. M. Newman**, general manager, **Radio Shack Corporation**, Boston, announces addition of three new members to company's staff—**Alton B. Eccles**, who will devote efforts to industrial sales and market analysis, and **William C. Allen** and **Frank Duplissa**, both of whom will work in advertising and sales promotion.

F. Sumner Hall, president, **AEN**, has entire industry's best wishes for rapid recovery from painful hospital stage **Jack Karns**, executive vice-president, **Revoton Corporation**, New York, announces advancement of **Barney Edwards** to national sales manager, and **Hank Miller** and **Vic Smiley** to manager of sales for Midwest and Pacific Coast, respectively...

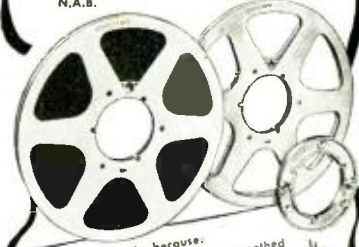
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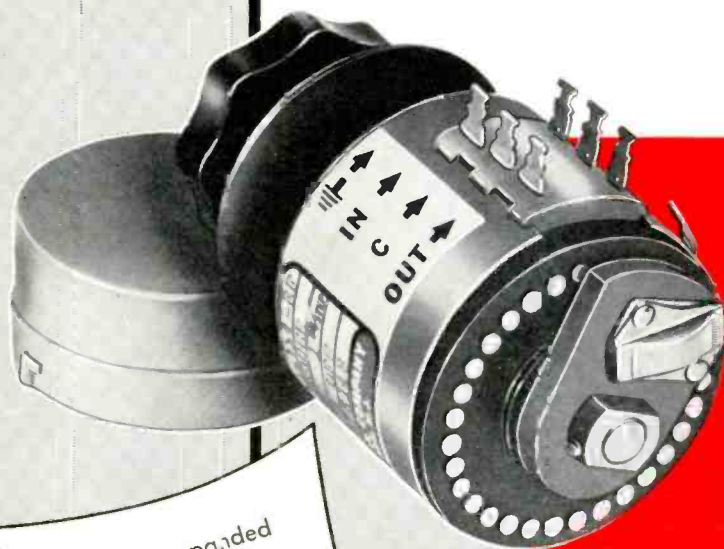
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A-11	Low impedance mike pickup, or line to 1 or 2 grids (multiple alloy shields for low hum pickup)	50, 200, 500	50,000 ohms	18.00
A-12	Low impedance mike pickup, or multiple line to grids	50, 125/150, 200/250, 333, 500/600 ohms	80,000 ohms overall, in two sections	16.00
A-14	Dynamic microphone to one or two grids	30 ohms	50,000 ohms overall, in two sections	17.00
A-20	Mixing, mike, pickup, or multiple line to line	50, 125/150, 200/250, 333, 500/600 ohms	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-21	Mixing, low impedance mike, pickup, or line to line (multiple alloy shields for low hum pickup)	50, 200/250, 500/600	200/250, 500/600	18.00
A-16	Single plate to single grid	15,000 ohms	60,000 ohms, 2:1 ratio	15.00
A-17	Single plate to single grid 8 MA unbalanced D.C.	As above	As above	17.00
A-18	Single plate to two grids. Split primary.	15,000 ohms	80,000 ohms overall, 2:3:1 turn ratio	15.00
A-19	Single plate to two grids. 8 MA unbalanced D.C.	15,000 ohms	80,000 ohms overall, 2:3:1 turn ratio	19.00
A-24	Single plate to multiple line	15,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-25	Single plate to multiple line 8 MA unbalanced D.C.	15,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	17.00
A-26	Push pull low level plates to multiple line	30,000 ohms plate to plate	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-27	Crystal microphone to multiple line	100,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-30	Audio choke, 250 henrys @ 5 MA 6000 ohms D.C., 65 henrys @ 10 MA 1500 ohms D.C.			12.00
A-32	Filter choke 60 henrys @ 15 MA 2000 ohms D.C., 15 henrys @ 30 MA 500 ohms D.C.			10.00



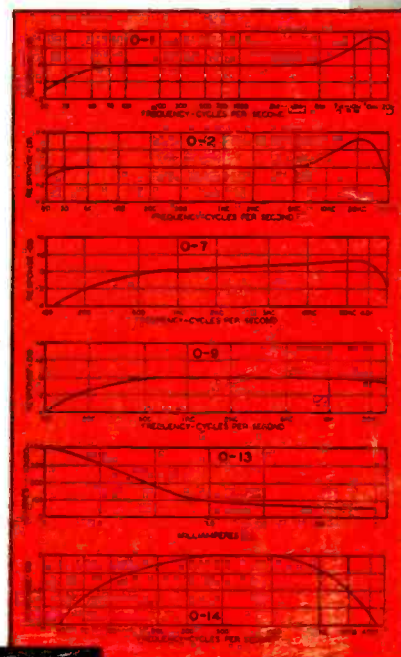
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Type No.	Application	Pri. Imp.	Sec. Imp.	List Price
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0-2	Mike, pickup or line to 2 grids	50, 200/250 500/600	50,000	14.00
0-3	Dynamic mike to 1 grid	7.5/30	50,000	13.00
0-4	Single plate to 1 grid	15,000	60,000	11.00
0-5	Plate to grid, D.C. in Pri.	15,000	60,000	11.00
0-6	Single plate to 2 grids	15,000	95,000	13.00
0-7	Plate to 2 grids, D.C. in Pri.	15,000	95,000	13.00
0-8	Single plate to line	15,000	50, 200/250, 500/600	14.00
0-9	Plate to line, D.C. in Pri.	15,000	50, 200/250, 500/600	14.00
0-10	Push pull plates to line	30,000 ohms plate to plate	50, 200/250, 500/600	14.00
0-11	Crystal mike to line	50,000	50, 200/250, 500/600	14.00
0-12	Mixing and matching	50, 200/250	50, 200/250, 500/600	13.00
0-13	Reactor, 300 Hys.—no D.C.; 50 Hys.—3 MA D.C.		6000 ohms	10.00
0-14	50:1 mike or line to grid	200	1/2 megohm	14.00
0-15	10:1 single plate to grid	15,000	1 megohm	14.00



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